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Using FORTRAN-80 for iSBC™ Applications

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I. INTRODUCTION

In March of 1978, Intel announced the availability of a resident FORTRAN compiler for the Intellec® Microcomputer Development System. In November of 1978, Intel announced the availability of a run-time package to support the execution of FORTRAN-80 compiled programs in the RMX/80™ environment. With this support package, user's of Intel's complete line of iSBC™ Single Board Computer products can benefit from the full set of I/O and math capabilities provided by the FORTRAN-80 language.

This application note is intended to familiarize the reader with the features, benefits and usage of the FORTRAN-80 package and RMX/80™ Executive. The reader who is unfamiliar with any of these topics is urged to refer to the related Intel publications listed in the front-piece.

Following the overview, two application examples will be studied. In the first example, FORTRAN code is used in a "stand-alone" environment; i.e., without operating system support. The second example is a multitasking system managed by the RMX/80 Executive which supports standard I/O interfaces to the RMX/80 Terminal Handler and Disk File System.

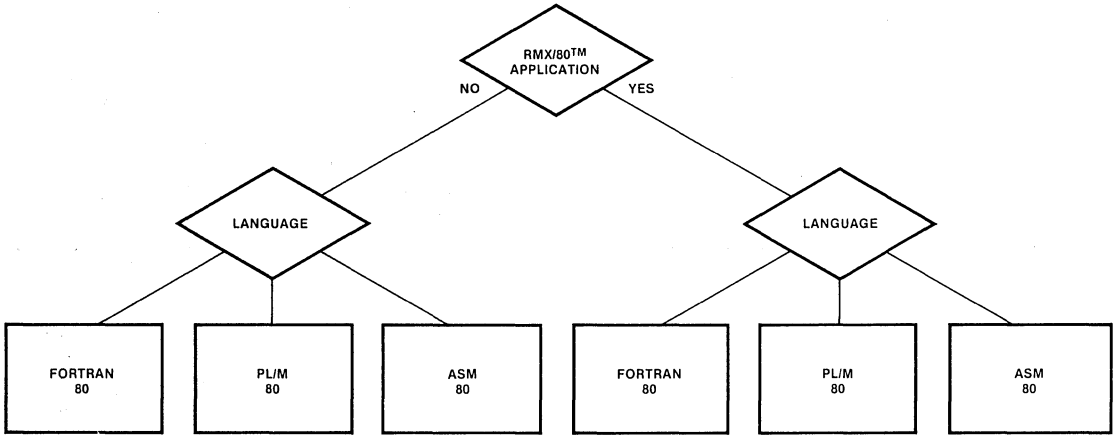
II. OVERVIEW

Intel's FORTRAN-80 compiler is an implementation of the standard FORTRAN known as ANS FORTRAN 77 approved by the American National Standards Institute (ANSI) in April, 1978. The implementation is of the FORTRAN 77 subset, plus most of the full I/O capability and Intel defined extensions. For a fuller description of the implementation, consult the *FORTRAN-80 Programming Manual.*

FORTRAN-80 is a high level applications programming language with flexible I/O handling and floating-point math instructions. With the FORTRAN-80 language, the programmer can easily implement sophisticated applications involving scientific calculations, process and instrument control, test and measurement, and a host of other applications requiring the power and flexibility the FORTRAN-80 language provides.

With the addition of the iSBC 801 FORTRAN-80 RUN-TIME PACKAGE for RMX/80 SYSTEMS, the user who wishes to implement his application using Intel's Single Board Computers and the RMX/80 Real-Time Multitasking Executive can take full advantage of the FORTRAN-80 I/O and math capabilities. The package allows the user to accelerate the run-time execution of FORTRAN-80 coded mathematical formulae through special interfaces to the optional iSBC 310™ High Speed Mathematics Unit. All disk and terminal I/O is interfaced directly to the RMX/80 Disk File System and either the full or the minimal Terminal Handler. The libraries that comprise the iSBC package are constructed in a modular fashion, allowing the user to configure systems with as much or as little of the support libraries as needed for a given application.

In order to effectively utilize the hardware and software products now available, it is important to design the application system from the top down. This implies that we need to think of an application in very general terms and then successively introduce more detail until we have program code as our final step. At each stage of the definition, we have to make decisions about the usage and configuration of various products.



The decision-making process that concerns itself with software can be shown as a tree (Figure 1). The first decision that must be made is whether or not the RMX/80 Real-Time Multitasking Executive should be utilized. In general, this package will prove extremely useful if the application to be designed must respond to multiple asynchronous events, or contains multiple, semi-independent processes that could be executed in parallel, or has need of standard vendor supplied device drivers. If the application is very small and simple, handles few or no interrupts, has no need for parallel execution of multiple processes, and the designer is willing to supply his own I/O device drivers, the program may be able to execute without the support of an operating system.

Whether the RMX/80 package is used or not, the system designer must now choose in which language or languages the programs should be coded. Each of the three languages shown is optimized for different purposes. The PL/M-80 language is well suited for systems programming. The ASM-80 language is best suited for applications requiring direct control of the computer (e.g., the registers and memory). The FORTRAN-80 language is highly desirable for those applications requiring mathematical calculations and formatted I/O. In many cases, the optimal solution will use a mix of two or even all three of these languages.

III. USING FORTRAN-80

I/O Capabilities

After the decision has been made to use the FORTRAN-80 language for an application, various types of I/O support are available to the user (see Figure 2). If the program code is to run without any support from an operating system, the user must supply drivers for any devices he wishes to include in his system.

When designing an RMX/80 system, the iSBC 801 package supplies the standard interface to the disk and terminal while the user may support additional devices in the same manner as the "stand alone" program would. The following sections expand on the topic of FORTRAN-80 I/O support.

Port I/O

The simplest and most direct method of performing I/O in the FORTRAN-80 language uses two pre-defined subroutines, INPUT and OUTPUT. The example below illustrates the use of these subroutines to input bytes from and output bytes to any of the 8080A/8085A I/O ports.

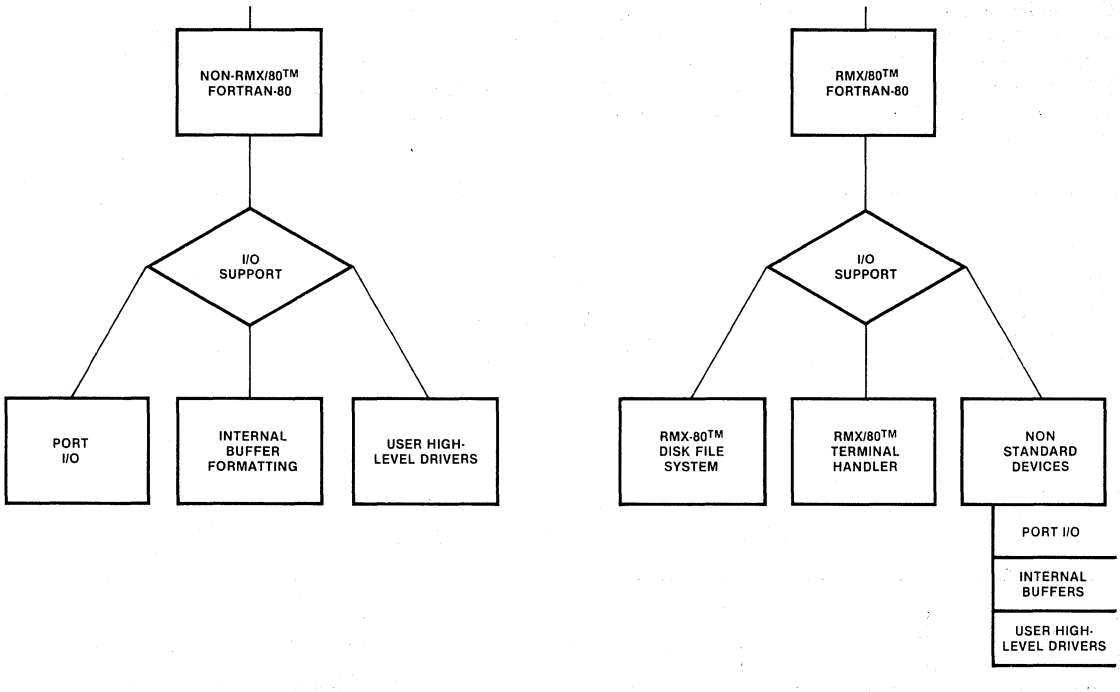


Figure 2. The I/O Support Decision

```
      INTEGER* 1 IVAL
C
C -- PROGRAM THE 8255 PARALLEL I/O CHIP
C -- PORT # = EB; VALUE = 94
C
      CALL OUTPUT (#0EBH, # 94H)
      •
      •
      •
C
C -- INPUT 8 BITS FROM PORT A INTO IVAL
C -- PORT # = E8; VALUE  INPUT TO IVAL
C
      CALL INPUT (#0E8H,IVAL)
      •
      •
      •
```

Port I/O is extremely useful in many applications. However, this method requires the programmer to directly handle each and every byte. Also, it does not utilize the power of the FORTRAN-80 formatting routines.

Internal Buffer Formatting

One method of overcoming the shortcomings of Port I/O is to use character strings as "virtual devices." This is accomplished by specifying a character string as the unit number in a READ or WRITE statement. External routines can be used to fill the character strings with input for the READ statement and to output buffers that have been formatted by the WRITE statement. The example below shows the use of this method.

```
      SUBROUTINE EXAMPL
      CHARACTER*80 BUFFER
      •
      •
      •
C
C -- CALL DEVICE DRIVER TO GET BUFFER OF
C -- CHARACTERS
C
      CALL BUFIN (BUFFER)
C
C -- NOW READ FROM BUFFER INTO VARIABLES
C -- UNDER FORMAT CONTROL
C
      READ (BUFFER, 100) X, Y, Z
100 FORMAT (F10.3, F12.4, F13.5)
      •
      • PROCESS DATA STORED IN VARIABLES
      • X, Y, Z
      •
C
C -- WRITE RESULTS TO BUFFER
C
      WRITE (BUFFER, 200) A, B, C, D
200 FORMAT (4F12.3)
C
C -- CALL DEVICE DRIVER TO OUTPUT BUFFER
C
      CALL BUFOUT (BUFFER)
      •
      •
      •
```

User Provided High-Level Drivers

If an application requires only simple input (READ) and output (WRITE) capabilities, the previous method would probably be sufficient. If, however, the device(s) in the system are more complex, it may be necessary to perform other I/O operations. One way of doing this would be to write subroutines for each operation. A much nicer solution is to use the FORTRAN-80 I/O instructions (OPEN, CLOSE, READ, WRITE, PRINT, BACKSPACE, REWIND, and ENDFILE) to interface to user-written routines which implement these instructions for the special device.

This is possible because, for each open file in the system, the FORTRAN-80 I/O system keeps a table connecting the unit number with the addresses of the routines that handle all operations on that unit. The I/O system allows the user to substitute his own device drivers into this table. To do this, the system designer codes a routine and labels it FQ0LVL. This routine is then made known to the I/O system (i.e., declared PUBLIC). Whenever a file is first accessed (i.e., OPENED), the I/O system calls FQ0LVL with a set of parameters, one of which is the file name referenced in the OPEN statement. The designer, in his code for FQ0LVL, scans the file name to decide if this is one of the files for which he wishes to supply drivers. If so, he passes back a table of the addresses of the routines that will take care of the eight primitive file I/O capabilities (refer to the example following this paragraph and to the *FORTRAN-80 Compiler Operators Manual*).

```
FQ0LVL: PROCEDURE(file$ptr,buf$ptr) BYTE PUBLIC;

/* table of entry point addresses for driver routines */

DECLARE table (8) ADDRESS DATA(
    .open$hdlr,     /* address of OPEN routine */
    .close$hdlr,    /* address of CLOSE routine */
    .read$hdlr,     /* address of READ routine */
    .write$hdlr,    /* address of WRITE routine */
    .back$hdlr,     /* address of BACKSPACE routine */
    .mv2rec$hdlr,   /* address of MV2REC routine */
    .rewind$hdlr,   /* address of REWIND routine */
    .make$eof$hdlr /* address of END OF FILE routine */
    );

DECLARE (returned$status,index) BYTE;
DECLARE (file$ptr,buf$ptr) ADDRESS;
DECLARE buf BASED buf$ptr (1) BYTE;
DECLARE file$name BASED file$ptr (1) BYTE;
DECLARE analog$in (*) BYTE DATA(':AI:');

/* set flag initially =FFH */

returned$status=0FFH;

/* if any character of file$name does not compare set flag=0 */

    DO index=0 TO 3;
    IF filename(index) <> analog$in(index) THEN
        returned$status=0;
    END;

/* if flag=FFH pass back the addresses of the drivers */

    IF returned$status=0FFH THEN
        CALL move(size(table),.table,buf$ptr);
    RETURN returned$status;
    END; /* of FQ0LVL */
```

RMX/80™ Support

When using the RMX/80 Executive, the iSBC 801 FORTRAN-80 RUN-TIME PACKAGE for RMX/80 SYSTEMS can be used to provide a direct interface to standard RMX/80 high level drivers, the Disk File System and the Terminal Handler. With the RMX/80 Executive, users can code multiple, concurrently executing programs that perform formatted I/O to disk files and the console, as shown in the following example:

```
C
C -- OPEN disk file
C
    OPEN (8,FILE = ':D0:TSTDTA.FIL',ACCESS =
    'SEQUENTIAL')
C
C -- perform tests
C
    •
    •
    •
C
C -- WRITE results to file for archival storage
C
    WRITE(8,100) (RESULT (I),I = 1,10)
100 FORMAT(10F12.3)
C
C -- PRINT completion message on console
C
    PRINT 200
200 FORMAT ('TESTS COMPLETE')
    •
    •
    •
```

If it is necessary for a FORTRAN program in the RMX/80 system to perform I/O to a device not handled by one of the high level drivers, any of the methods previously described can be utilized to augment the I/O system.

FORTRAN-80 Math Capabilities

The FORTRAN-80 language supports four data types labelled INTEGER, REAL, LOGICAL, and CHARACTER. Also supported are various operators which can manipulate objects of various types. Both INTEGER (fixed point) and REAL (floating-point) objects can be manipulated by the add (+), subtract (−), multiply (*), divide(/), and exponentiation (**) operators. In addition, Integers can be operated on by the Boolean operators (e.g., .AND.,.OR.). In this case, the operations are performed bit-wise on the operands.

All floating-point arithmetic operations are performed with algorithms that adhere to the Intel Floating-Point Standard[1] which allows for seven decimal digits of precision. Whenever math operations are used, the user can make the decision to use a software package to implement the floating point support or to accelerate the execution of these operations (by as much as a factor of five or six) by installing an iSBC 310 High-Speed Mathematics Unit and linking in special FORTRAN-310 drivers. In either case, due to the adherence to the standard, the results of all calculations will be identical. In addition, the libraries have been designed to allow the switch to be made from software routines to a faster hardware solution with *no* code changes.

Above and beyond the basic mathematical operators in FORTRAN-80, a large number of intrinsic functions are available. These functions provide services like type conversion, remaindering, and logarithmic and trigonometric calculation. Since the calculations involved in performing these high-level functions require the mathematical operators, they too can be accelerated by the inclusion of the iSBC 310 board and its associated drivers.

Error Handling

The math processing system also provides flexible error handling. The user can choose to use either an Intel-supplied error handler or one of his own design. The capability also exists to change the active error handler dynamically in cases where different routines require different handlers. The default error handlers are named FQFERH. One exists in each of the arithmetic libraries (Figure 3). This error handler will attempt to recover from an error by taking the most reasonable action (e.g., underflow error returns result = 0). If code is being run "stand-alone" or under the RMX/80 executive the handlers in the math libraries should be used or the user should supply his own. Appendix B of the *ISIS-II FORTRAN-80 Compiler Operator's Manual* contains all of the information necessary to implement a custom error handler or to use the default routines.

FPSOFT.LIB	- Software package for "stand-alone" and ISIS-II systems
FPHARD.LIB	- iSBC 310 drivers for same
*FPSFTX.LIB	- Software package for RMX/80 systems
*FPHRDX.LIB	- iSBC 310 drivers for iSBC 80/20, 80/20-4 and 80/30 boards
*FPHX10.LIB	- iSBC 310 drivers for iSBC 80/10 and 80/10A boards
FPEF.LIB	- Library of routines implementing intrinsic functions

*Available in iSBC 801 FORTRAN-80 RUN-TIME PACKAGE for RMX/80 Systems.

Figure 3. Available Math Libraries

1 Palmer, John F., "The Intel Standard for Floating-Point Arithmetic," *Proceedings of the First International Computer Software and Applications Conference* (Chicago: IEEE Computer Society), November, 1977, pp 107-112.

IV. APPLICATION EXAMPLE

An Automated Test Stand

This example shows the steps taken to design and implement an automated test stand. The hardware system must interface to a test fixture upon which test items can be mounted. Operator inputs and test outputs involve a 300-baud hard copy terminal. The software to be developed must allow an operator to invoke a variety of tests from the console and to receive some printed performance record for the object under test. In addition, the software must allow for tests to be added and deleted often, and each test must be allowed to obtain any number of parameters from the command line tail.

After examining the problem definition and the decision making diagram presented earlier, it was decided that this application could be implemented with a simple sequential program.

Since formatted I/O and mathematical calculations are involved, the FORTRAN-80 language is well suited to be the main programming language. Also, some ASM-80 routines will come in handy for communicating with the console.

An analysis of the I/O to be performed breaks down into two distinct types. Various inputs to and outputs from the text fixture will be 8-bit parallel transfers. These will likely go through the 8255A ports on the Single Board Computer. Port I/O will be used to handle this function. Interface with the operator requires READ'S AND WRITE's to the console device. The simplest way of performing this function is to use character strings as the target of READ and WRITE operations and coding small ASM-80 routines to transfer these buffers from/to the console.

A diagram of the test stand is shown in Figure 4. The computer hardware necessary to solve this application includes a Single Board Computer (the iSBC 80/20 board), a PROM memory module and an analog I/O board. Digital I/O with the test fixture is handled by the 8255A ports on the Single Board Computer. The analog inputs on the test fixture come from the two D/A converter channels on the iSBC 732 board.

The software solution utilizes a very rudimentary command line interpreter. The mainline routine gets a line of input and finds the first non-blank character. If this character is an alphabetic character, it is used in a computed GOTO statement to transfer control to one of a possible 26 entry points. Tests may be added by choosing a keyletter and inserting a label in the GOTO statement to transfer control to the new test routine. The command input line and the index in the line are stored in a common block so that any test routine can continue scanning the line for parameters or can reset the index and find out what keyletter caused its invocation. The flow of the software is illustrated in Figure 5.

For the purpose of explanation, routines are shown to implement a "calculator mode" which allows the operator to perform arithmetic from the console, and a logic transition tester which determines whether the object on the test fixture changes state at the proper voltages.

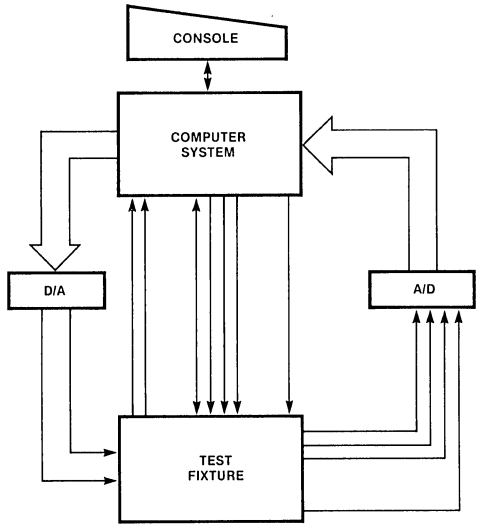


Figure 4. Test Stand Diagram

Code Description

The following sections describe the program code for this application example. Fold-out code listings are contained in Appendix A. The circled reference letters in the text refer to the corresponding letters in the listings.

The DRIVRS Module

The module DRIVRS contains three primary routines. START (A) is located at 0 so that it is executed upon power up. This routine is responsible for programming the on-board hardware (8255A, 8251, 8253), setting up the system stack, and calling the FORTRAN routine labeled MAINLN.

The input routine BUFIN (B) is called from FORTRAN routines with a character string as an argument. Note that passing a string argument from FORTRAN results in the address and length of the string being sent as parameters. The string is filled with characters input from the console until a carriage return is encountered. A simple line-editing scheme is implemented allowing character deletion (RUBOUT), line deletion (CONTROL-X), and echoing of the current buffer contents (CONTROL-R). Attempted entry of characters beyond the end of the string and RUBOUTS past the beginning cause the audible bell to sound.

The output routine, BUFOUT (C), also takes a character string as an argument. The entire contents of the string are sent to the console unless a carriage return is encountered in the string. If a carriage return is the terminator, a line feed is output as well. If a CONTROL-S is entered at the console while output is in progress, output is suspended until a CONTROL-Q is typed.

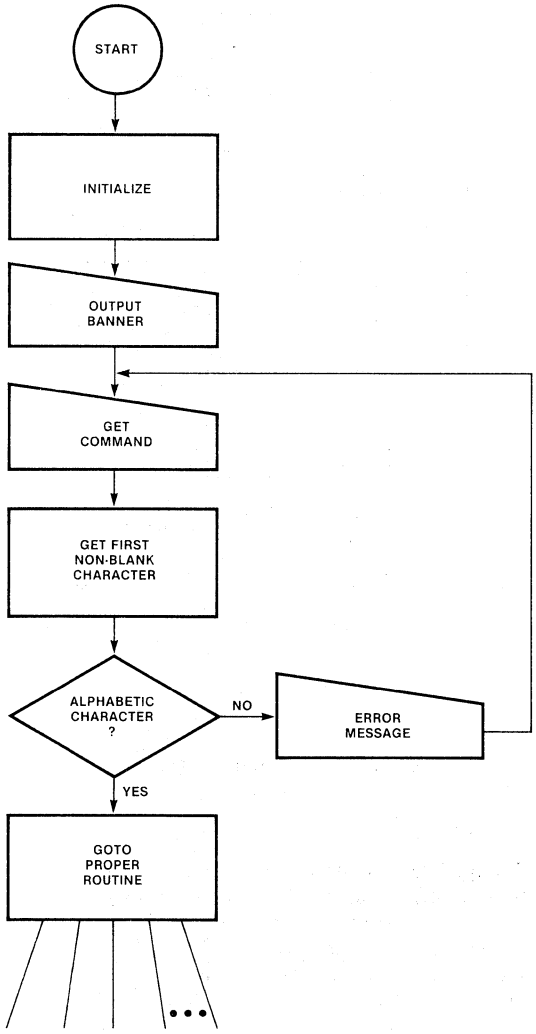


Figure 5. Flow Diagram

The MAINLN Module

The module MAINLN (D) contains the mainline routine that implements the command line interpreter. The statement IMPLICIT LOGICAL A-Z will cause most usages of undeclared variables to be reported as illegal mixed mode; the intent in writing these programs was to declare all variables, which is generally considered good programming practice, even though Fortran makes default assumptions about undeclared variables.

The default handler is to be used for any errors that may occur while performing mathematical calculations. Also, the routines that perform the calculations must be initialized. Both of these operations are performed by the call to FQFSET (E). The call takes two arguments. The first argument is a two byte field specifying which error handler is to be used. If the low order bit of the high order byte is a one (e.g., 100 hexadecimal), the math routines will call a user error handler whose address is given as the second parameter. If the low order bit is zero (as is the case in this example), the routines will use the default handler and ignore the second argument.

A banner is output to the console by the sequence at (F) where a formatted WRITE is performed on an internal buffer (IMAGE) and then the external driver BUFOUT is called to output the buffer to the console. The variable CARRET is used to insert a carriage return into the string to be output. In order to allow individual characters in the character string to be accessed, the EQUIVALENCE statement is used to cause LINBUF and IMAGE to occupy the same memory space. The variable INDEX (G) is used to scan through the input buffer.

A call to BUFIN (H) fetches the command line from the console. DBLANK is called (I) to position INDEX to the first non-blank character. This character is converted to its integer representation, normalized to 1 and checked to see if it is a valid alphabetic character (J). If the keyletter is valid, the computed GOTO (K) causes execution to branch to the correct point in a jump table (L). Note that A (add,) S (subtract), M (multiply), and D (divide) all branch to a single routine MATH, T (transition test) branches to a routine called TRANST and all other keyletters are trapped into line 100. Any and all I/O errors cause the ERROR routine to be called.

The DBLANK Module

The DBLANK routine (M) de-blanks the input line. If a carriage return is encountered, the operator is prompted for more input.

The ERROR Module

The ERROR routine (N) prints out an error message, with the error number, to the console.

The MATH Module

In many of the tests, the human operator must supply numeric parameters. A calculator mode is supplied for the simple calculations that might be needed here. This mode is implemented through the MATH routine (O). Since any one of four keyletters could have caused this routine to be invoked, MATH rescans the command line to obtain the keyletter (P). Following this, two operands are read in by calls to CONVRT (Q) and the operation requested is performed on them.

The CONVRT Module

Subroutine CONVRT (R) is called from other routines to extract floating-point operands from the input line buffer. Characters are transferred into a temporary buffer (S) until either a carriage return or a comma is encountered. The temporary buffer is then read under format control to obtain the returned value (T) .

The TRANST Module

The item to be tested is composed of combinatorial logic as shown in Figure 6. The transition test sets all inputs except one to a constant value. By varying the voltage at the remaining input, the transitions at the output can be checked. This test must be run while the +5V power to the fixture is varied through a range of values. This testing is performed by the TRANST routine.

Power is supplied to the test fixture through one of the two D/A channels on the iSBC™ 732. Three of the input parameters specify the starting and stopping voltage values for Vcc and the increment to be added each step. The fourth parameter is the tolerance to be used to decide if the test passes or fails at each step. Once the test is running, the output voltage at (2) is measured for inputs at (1) of 0 and 5V. The voltage input is then incremented from 0V (using D/A channel 1) until a transition is sensed in the output voltage at (2) . At this point, the input voltage at (1) is checked to see if it is within tolerance. The same process is then repeated with the voltage at (1) going from +5V downward. After the test is complete, a formatted report is generated containing the ambient temperature (measured through a temperature sensor) and the performance record for the item under test.

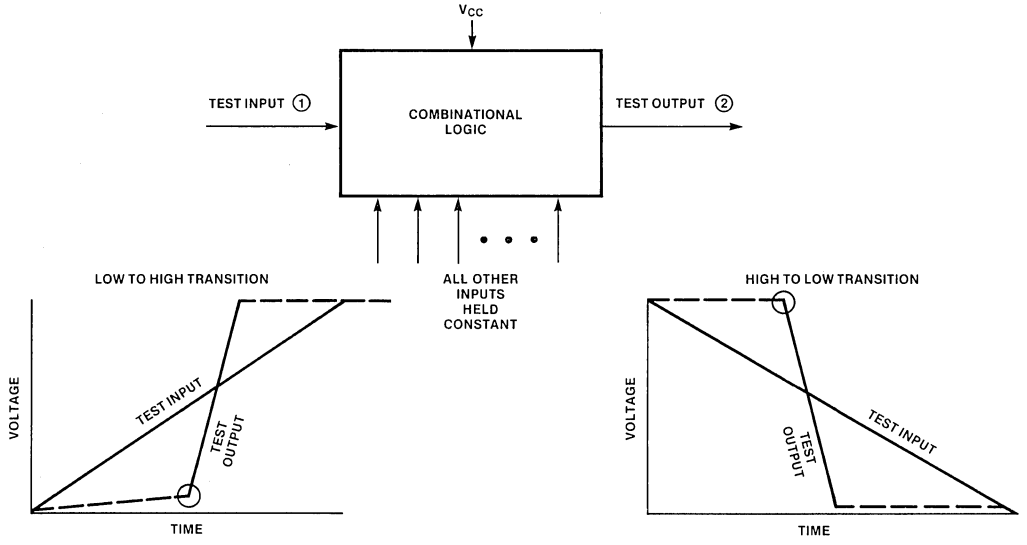


Figure 6. Transition Test

```
TEST STAND V0.0
COMMAND?
M 34.678,345.43
          34.678000 *          345.43000 =          11978.82160
COMMAND?
T 4.5,5.5,.2,5.
TRANSITION TEST  TOLERANCE=  5.0% AMBIENT TEMPERATURE = 25.30 DEGREES C
    VCC     HIGH TRANS   LOW TRANS   HIGH    LOW     TEST
    4.5       00.81        3.42      4.43    0.12    PASSED
    4.7       00.80        3.44      4.67    0.08    PASSED
    4.9       00.80        3.67      4.88    0.02    PASSED
    5.1       00.80        3.71      4.93    0.02    PASSED
    5.3       00.80        3.73      4.98    0.01    PASSED
    5.5       00.80        3.74      4.99    0.01    PASSED
COMMAND?
```

Figure 7. Sample Output

An external routine (U), ADCIN, is called to input samples into the variable given as the first parameter from the channel given as the second parameter. The counts from the temperature sensor exhibit a logarithmic curve, so the input is linearized using the equation shown. The routine DACOUT (V) takes the first parameter and outputs it to the channel specified by the second parameter. If no transition occurs when the test input is run through its entire range, the item is assumed non-functional, a message is output, and control is returned to the console (W).

The ADCIN Module

Subroutine ADCIN (X) fetches samples from the A/D converter on the iSBC 732 board. The channel number is an input parameter and the data is the returned value. Of special note in this routine is the use of the FORTRAN common block to control a memory-mapped device. The master CPU communicates with the iSBC 732 by way of memory read and write commands instead of I/O commands. The primary reason for this is the fact that the 8080A IN and OUT instructions operate on only 8 bits at a time whereas SHLD and LHLD instructions can manipulate 16 bit operands. This is convenient when working with 12-bit inputs from the A/D and 12 bit outputs to the D/A. In the code, a common block is created which has the same makeup as the memory mapped registers on the iSBC 732 board. The common block will be origined at the address of the iSBC 732 by the ISIS-II LOCATE program.

The DACOUT Module

Subroutine DACOUT (Y) makes use of the same common block to output given values to a specified D/A channel.

LINK and LOCATE

The ISIS-II LINK command needed to pull together the individual pieces of this example is shown in Figure 8. After compilation, the object modules of all of the previously described routines are placed in the library FRTMOD.LIB by the ISIS-II Library Manager™. The LINK statement starts with the module DRIVRS.OBJ, which has one EXTERNAL reference, MAINLN. To satisfy this reference, MAINLN.OBJ is linked in from FRTMOD.LIB and its EXTERNAL references cause the inclusion of other modules.

The LOCATE command shown in Figure 9 is used to assign absolute memory locations to the code in the LINKED modules. The common block labelled ADC is explicitly assigned to FFF0H so that it will correctly overlay the memory-mapped space of the iSBC 732 board. The ORDER statement is used to tell the locator in what order the various segments should be placed in memory.

```
LINK :F1:DRIVRS.OBJ, &
     :F1:FRTMOD.LIB, &
     :F0:F80RUN.LIB, &
     :F0:F80NIO.LIB, &
     :F0:F80ISS.LIB, &
     :F0:FPEF.LIB,   &
     :F0:FPSOFT.LIB, &
     :F0:PLM80.LIB   &
TO :F1:TSTND.LK0 PRINT(:F1:TSTND.LNK) MAP
```

Figure 8. LINK Command for Test Stand Example

V. USING THE FORTRAN-80 RUN-TIME PACKAGE FOR RMX/80™ SYSTEMS

The iSBC 801 package provides I/O interface and math routines for users who are coding RMX/80 applications in the FORTRAN-80 language. In the following sections, an overview of the RMX/80 system will be presented along with a discussion of the use of the iSBC 801 package. This overview is not intended to be exhaustive. If the reader is unfamiliar with the RMX/80 package, he should gain from this section enough understanding to comprehend the concepts in the example presented. If the reader is planning on implementing an RMX/80 system, the RMX/80 references in the frontpiece should be studied carefully.

```
LOCATE :F1:TSTND.LK0 PRINT(:F1:TSTND.LOC) MAP LINES SYMBOLS PUBLICS &
ORDER(CODE DATA /LINE/ /ADC/) /ADC/(0FFF0H) STACKSIZE(0) CODE(0)
```

Figure 9. Locate Command for Test Stand Example

Overview of the RMX/80™ Executive

A large number of microcomputer applications require the ability to respond to events in real-time. The RMX/80 Executive provides the system software around which you can build a real-time multitasking application using Intel iSBC 80™ Single Board Computers. In addition, the RMX/80 package provides the application designer with various high-level drivers (such as a terminal handler and a disk file system) which make it easier to develop sophisticated applications software.

The RMX/80™ Model

At this time, it is appropriate to discuss the RMX/80 model, or in other words, the general concepts upon which the RMX/80 Executive is built. Real-time systems, such as the RMX/80 system, provide the capability to control and respond to events occurring asynchronously in the physical world. To handle these events, the application is broken up into smaller semi-independent pieces, and each of these pieces is brought into action to handle the event for which it is intended. Each of these independent program units is a *task*. The RMX/80 Executive manages the execution of these tasks in accordance with a user-designated priority scheme to insure that the highest-priority task in the system has control of the CPU. It is also necessary, in a system such as this, for these semi-independent program units (tasks) to communicate with each other. This communication may be for the purpose of synchronization, data passing, mutual exclusion or any other use that may arise. To facilitate inter-task communication, the RMX/80 model incorporates the notion of messages and exchanges. A *message* is a data structure that can contain an arbitrary amount of information to be communicated from one task to another. An *exchange* is a "mail box" where tasks may send messages to be picked up by other tasks. The primary operations (primitives) that accomplish message transfers in the RMX/80 system are RQSEND* and RQWAIT*. Figure 10 diagramatically shows the interaction of tasks, messages, and exchanges and introduces the symbolism used to represent these RMX/80 concepts in the system design.

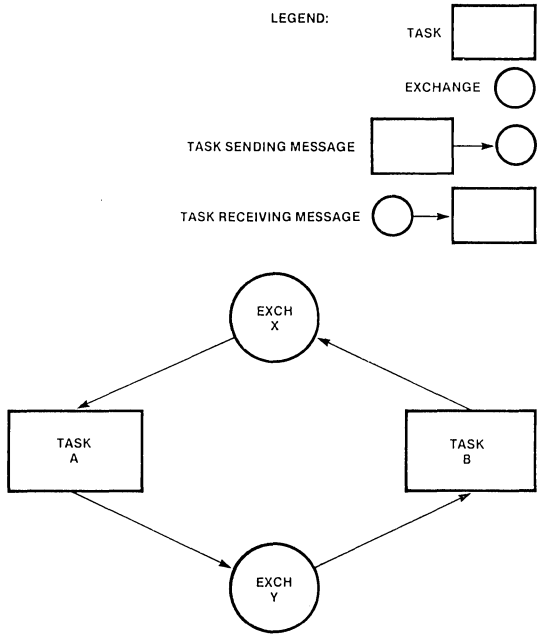


Figure 10. Task, Message, Exchange Interaction

Tasks

Typically, a task will execute a section of code that performs some initialization and then enters an infinite loop performing some processing over and over again as shown in Figure 11.

Each task in the system has a priority associated with it. The RMX/80 Executive uses this priority scheme to determine which ready task to run. The assignment of priorities to individual tasks is up to the system designer, giving him the capability to tune his system by assuring timely execution of important functions.

```
      SUBROUTINE TASK1
C
C -- DECLARATION OF VARIABLES HERE
C
C
C -- INITIALIZE VARIABLES AND I/O PORTS
C
      CALL OUTPUT (#0E8H,0)
      FLAG = 1
      INDEX = 1
      COUNT = 0
      SUM = 0
C
C -- ENTER INFINITE LOOP
C
1     CALL INPUT(#0E9H,IVAL)
      •
      •
      •
      GOTO 1
      END
```

Figure 11. Task Loop

*In order to differentiate RMX/80 procedures and data structures from the user's, the names of system objects are always preceded by RQ.

Each RMX/80 task also has its own stack, and there is no system stack. Whenever a task must give up the processor (e.g., must wait for the occurance of an interrupt) all of the information necessary to reawaken it at some future time without affecting the results of it's processing is stored on its stack.

Exchanges

An *exchange* in the RMX/80 system is a data structure that contains pointers to lists of tasks and messages. Whenever a message is sent to an exchange where there are no tasks waiting, it is added to the list of messages at that exchange until a task accepts it. Similarly, if a task waits at an exchange for a message and there is no message in the list, the task is added to the list of tasks waiting at that exchange. In both cases, the tasks and messages are serviced on a first come, first served basis. Figure 12 shows the possible states an exchange may be in at a given time.

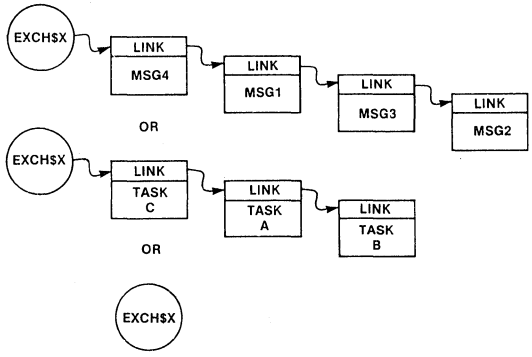


Figure 12. Exchange Lists

Messages

A *message* in the RMX/80 system is a contiguous section of memory of an arbitrary length. Information can be stored in the message prior to it being sent to an exchange where it will be accepted by another task.

Configuration

The configuration module contains various tables and PUBLIC variables that are accessed by the system at start-up time. All of the necessary information on the tasks and exchanges to be created and the disk file system to be utilized are contained in this section of code. Configuration modules can be coded in either PL/M or assembly language (for which there are macros included with the RMX/80 product.)

Memory Usage

In systems using disk, it is necessary to ensure that certain buffers used by the disk controller for Direct Memory Access (DMA) are located in memory that is accessible to the disk controller. The buffers needed are allocated in a separate module called the *controller addressable memory* module. In the case of the iSBC 80/10, 80/10A, 80/20, and 80/20-4 boards, this module should be LOCATED before being included in the LINK statement to make sure that it does not contain any RAM on the CPU board itself (and, therefore, not controller-addressable). This restriction does not apply to iSBC 80/30 systems, since the iSBC 80/30 board has a dual port bus allowing system access to on-board RAM.

VI. APPLICATION EXAMPLE

A Sewage Treatment Plant Control System

In the early 1900's, the most popular type of sewage treatment system was known as a Sequencing Batch Reactor. It provided excellent effluent quality, but as populations grew, the amount of control necessary to operate the plant became too great for human operators, and a new type of treatment system came into use. This new system did not require such accurate control, but it also did not perform as well. With the passage of stricter and stricter water quality laws, and with the advent of low-cost, high powered microcomputer control systems, a serious look is being taken once again at Sequencing Batch Reactors.

A diagram of the treatment system and its sensors and actuators is shown in Figure 13. The system usually consists of three tanks, with each tank having individual influent and effluent valves, mixers and aeration equipment.

At any given time, all influent is being routed to one tank. When this tank is filled, the influent is routed to one of the other two. The full tank is agitated and aerated until the bacteria in the tank digest the sewage to within given limits. At this time, the mixer and aerator are turned off and the contents settle. After a time, the supernatant fluid is drawn off leaving the layer of concentrated bacteria to digest the next batch.

The computer control system necessary for controlling these reactors is shown in Figure 14. The system is responsible for monitoring the various sensors and contact closures, maintaining archives of system status, logging reports upon command, activating operator alarms, and performing on-line control of the batch cycle.

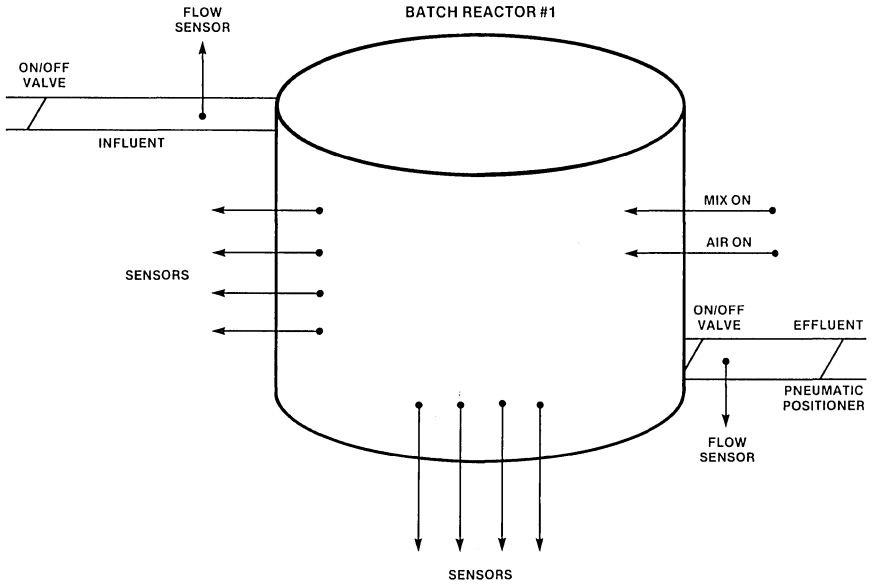


Figure 13. Sewage Treatment System and Sensors

Software

An analysis of the functions that need to be performed by the software for this control system leads to a decision to use the RMX/80 Executive. Timely response to multiple asynchronous events is the main thrust of this application. A breakdown of the individual functions in the system would be:

- *data collection* — gathers inputs from the sensors and contact closures and stores them where other routines can access them. Also, converts data from analog counts to engineering units.
- *on-line control* — based on current sensor inputs determines whether aeration, agitation, discharge and fill should be on or off.
- *alarm scanning* — compares current status values with setpoints and sets operator alarms if conditions are out of tolerance when effluent is on.
- *data logging* — once every five minutes logs current system status into a disk file record.
- *real-time clock* — maintains day, month, year, and time of day.
- *operator console handler* — monitors operator console to detect operator commands for time and setpoint changes, report generation, alarm clearing, etc.
- *report generation* — upon operator command, formats either the file corresponding to yesterday's operation or today's operation to the current moment.

Each of these functions must be studied independently before the decision on which language to use for each is made. The functions concerned with data collection, on-line control, and alarm scanning will be concerned with mathematical calculations. The functions concerned with data logging and report generation will have need of formatted disk and console I/O. These routines will thus be coded in the FORTRAN-80 language.

As was mentioned earlier, the PL/M-80 language is a systems programming language. This means that it is optimized to deal with the concepts embodied in a high-level system such as the RMX/80 system. The program code that implements the real-time clock and operator console handler will be written in the PL/M-80 language. In addition, various PL/M-80 support routines will be written to be called on by one or more of the FORTRAN-80 routines. The purpose of these routines will be explained as they come up in the code descriptions following.

Hardware

The hardware used to implement this control system must perform the following functions:

- inputting analog samples from the various sensors
- outputting analog values to the pneumatic positioners
- inputting digital values from the contact closures and operator console
- outputting digital values to the operator console and alarm panel
- storing and retrieving data from diskette files

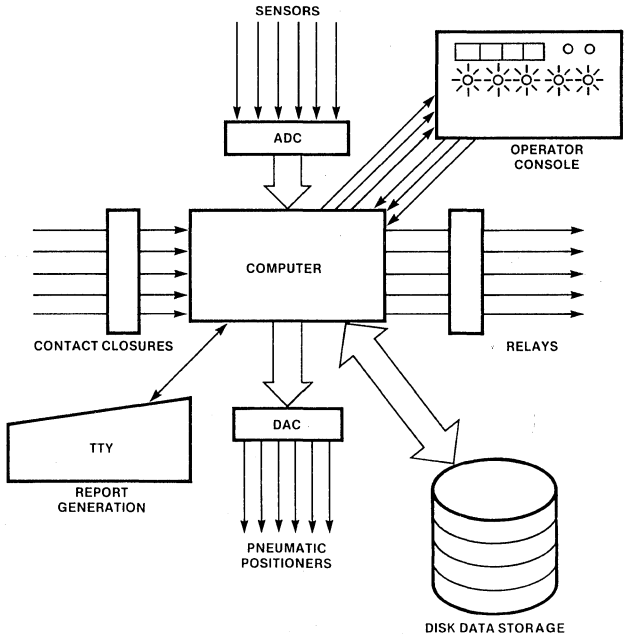


Figure 14. Computer Control System

The hardware configuration chosen includes an iSBC 80/30 Single Board Computer, an iSBC 732 Combination Analog Input/Output Board, a combination of PROM and RAM memory modules, and an iSBC 201 Diskette Controller.

There are various types of I/O devices in this system and each will require different FORTRAN-80 I/O support. The terminal and disk devices are supported through the iSBC 801 run-time package and the RMX/80 high level drivers. Communications with the A/D and D/A converters is accomplished using internal buffer formatting in conjunction with the RMX/80 Analog Handlers. Finally, port I/O is used for the digital inputs and outputs.

The next step in the design is to assign the system software functions to individual tasks in a manner that will allow for their parallel execution. The following tasks will be created to handle this application:

- STSINP — status input and unit conversion
- CNTROL — on-line control
- SCAN and TIMER5 — alarm scanning and data logging
- TIMER and TIMUPD — real-time clock
- CONSOL — operator console handler
- REPORT — report generation

Figure 15 shows the interaction of these tasks in the RMX/80 system.

System Considerations

At this point, let us consider some of the mechanisms this system will require to synchronize and co-ordinate the tasks we have created. Status and setpoint information will be stored in FORTRAN common blocks. This will allow the STSINP, CNTROL, SCAN, CONSOL, and TIMUPD tasks access to the STATUS information, and the CNTROL, SCAN, and CONSOL tasks access to the SETPNT information. Once per five minutes, SCAN will be notified through a flag byte (MIN5UP) that he is to write the current system status to the file TODAYS.RPT. Upon command from the operator, REPORT will need to read these files to generate reports.

Since the RMX/80 system is designed to handle asynchronous events, it is quite possible for any of the tasks to be pre-empted at any point in their execution (e.g., an interrupt occurs or a higher priority task becomes ready to run). Thus, the SCAN task may be in the process of reading the last byte of a four-byte REAL integer when STSINP pre-empts the SCAN task and writes new information into the STATUS common block, thus invalidating the current SCAN operation. In another instance, REPORT may be in the process of fetching a disk record when SCAN attempts to write to the file. For these reasons, and more, it is necessary to implement some sort of synchronization mechanism in this system. We will insure that at most, one task has access to the common blocks and disk records by using a technique called *mutual exclusion*. In the RMX/80 system, this is accom-

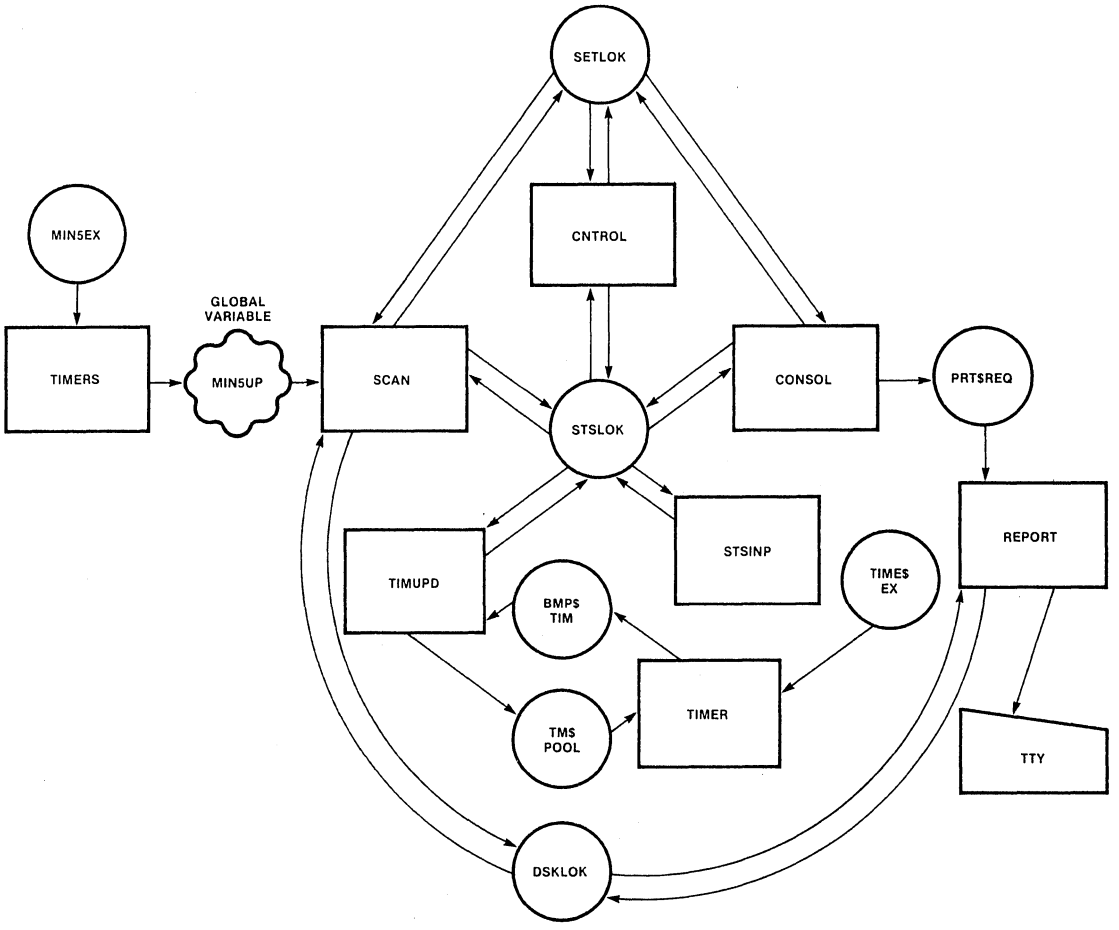


Figure 15. System Design Diagram

plished by creating an exchange for each shared resource and initially sending one message to it. Any task requiring access to the resource first waits at the associated exchange for the key message. If a message is at the exchange, the task obtains the message and continues running until finished and then sends the message back. If another task waits at the exchange while the first is processing, it will stop execution until the first task finishes and returns the message.

Code Descriptions

What follows is a description of the code used to implement most of the tasks discussed. Appendix B contains fold-out code listings with circled reference letters. In the description, sections of the code will be called out using circled letters that correspond to symbols in the appendix.

The Semmod Module

Two PL/M routines called LOCK and UNLOCK perform the mutual exclusion operation discussed earlier. There are three exchanges used for the purpose of exclusion: STSLOK, SETLOK, and DSKLOK. They govern access to the STATUS common block, the SETPNT common block and the disk file respectively. The LOCK procedure (A) takes one parameter, a number representing one of the three exchanges, and performs a wait at the appropriate exchange. Note the use of based variables to access the parameter. This is necessary since FORTRAN passes parameters by reference (address) rather than by value. The UNLOCK procedure (B) takes the same parameter and sends the single key (message) back to the appropriate exchange.

These routines are written in the PL/M language because they must deal directly with a few system concepts that the FORTRAN-80 language does not. In particular, the RQWAIT routine returns to the caller the address of the message received from the exchange. In either the PL/M-80 or ASM-80 languages this address can be used to access the information in the message received. FORTRAN-80 routines do not have the capability to use address values to access data outside of their own module.

The STSINP Module

The module STSINP (C) performs the function of updating the STATUS common block with new data from the sensors that has been converted to engineering units. STSINP initializes the FORTRAN-80 math routines (D) and directs them to use the default error handler. STSINP then calls INIT$IO (E) which initializes the message that will be used to communicate with the RMX/80 Analog Input Handler. The call to SMPLIN (F) fills the buffer with analog samples from the sensors, and the following DO loop right-justifies the 12-bit samples in the 16 bit field (G) . STSINP now waits for access to the STATUS block, converts the samples, stores them, inputs and stores the values of the contact closures and calls UNLOCK (H) . The function performed by STSINP is not a continuous function. Update of the status information once per second is sufficient. The call to WAIT (I) delays execution for one second.

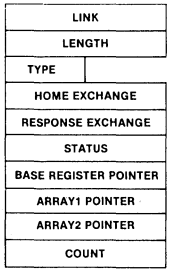


Figure 16. Request Message for Sequential Channel Input with Single Gain

The ANALOGIOMOD Module

In the module labelled ANALOGIOMOD, the declaration of READ$MSG (J) uses the predefined LITERAL called AI$MSG. This LITERAL is one of many in the RMX/80 package that can be used to attach meaningful symbolic names to PL/M data structures. In this instance, AI$MSG defines the fields of a standard analog input request message. Figure 16 is a diagram of the individual fields of the request message. The definition and usage of each of these fields is described in the *RMX/80 User's Guide*. The procedure INIT$IO (K) is called by STSINP. It simply initializes the analog input request message and returns. Note the assignment operation in line 29. The RESPONSE$EXCHANGE field of the request message must contain the address of the exchange where the RMX/80 Analog Handler should send the response to the request (see Figure 17 for a diagram of the request-response mechanism). In the PL/M language, this address is assigned using a location reference - a variable name preceded by a period, which stands for the address of the variable. FORTRAN-80 routines lack the ability to refer to the address of variables.

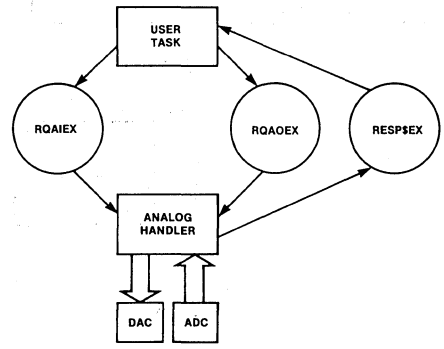


Figure 17. Request/Response Mechanism

The procedure SMPLIN (L) fills in a buffer, given as an input parameter, with analog samples from sequential channels on the A/D. Note the mechanism used to handle the passing of a FORTRAN string as a parameter. For every string in the parameter list, FORTRAN passes the starting address of the string followed by its length in bytes.

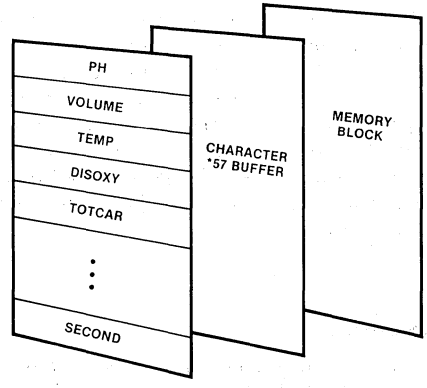


Figure 18. Use of EQUIVALENCE Statement

The SCAN Module

The SCAN task is responsible for operator alarms and data logging. The EQUIVALENCE statements (M) cause the STATUS common block to be overlaid by a character string, as illustrated in Figure 18. This allows for a compact file on disk of numerical data which can be broken out later for report generation.

After initialization, SCAN waits for access to both the STATUS and SETPNT common blocks. Operator alarms need to be set only if a parameter is out of specification and the effluent pump is on (N) . After performing the scan, the variable MIN5UP is checked (O) to see if a report should be logged. If so, SCAN gains access to the disk file and writes a single record (P) . All locks are now released, a one-second delay is counted out, and SCAN repeats the whole process. Normally, any errors that occur during the execution of I/O statements in the run-time package cause a message to be output on the console and the offending task to be suspended. Since this action is often undesirable, it is wise to handle one's errors programatically (Q) .

The MIN5MOD Module

The module MIN5MOD contains two procedures. Both routines make use of the timed wait facility in the RMX/80 system. Any time a task calls RQWAIT to wait for a message at an exchange, an optional time limit (in 50 msec. intervals) can be specified. This is useful if the designer does not wish the task to be hung up forever if a message is never sent to that exchange. This mechanism can also be used to implement a timed wait if an exchange is specified to which no one will ever send a message. WAIT (R) delays execution of the calling task for one second. TIMER5 (S) waits for five minutes and then sets the variable MIN5UP to signal SCAN to log a disk record of current status.

The REPORT Module

The system console contains two buttons, one each for requests for printouts of today's and yesterday's status reports. Whenever one of these two buttons is pushed, the CONSOL task sends a message to the PRTREQ exchange with the TYPE field indicating which file to print. REPORT accepts these messages, checks the TYPE field (T) , and calls the FORTRAN subroutine PRINT with the appropriate filename as a parameter. It then returns the request message to its sender via the response exchange field and waits for another request. Figure 19 is an example of the report generated by this system.

The PRINT Module

The PRINT subroutine will read in the compressed records written by SCAN and use the same set of EQUIVALENCE statements to break out the numerical data so that it can be formatted for printout. If the type field (U) indicates that today's file is being accessed, PRINT obtains the key to the DSKLOK exchange since SCAN may disturb output operations if it attempts to log a new record. If yesterday's file is being accessed, the lock is not necessary, since no other task will be accessing this file. Once the lock is obtained, a record is read, the digital value of the contact closure status is converted to a more readable form (V) (ON or OFF), and the status line is formatted and printed. Since the SCAN task has an important function (operator alarms), we do not wish to hold it up for long if it happens to want to log a new status record. For this reason, PRINT relinquishes access to the file after every tenth record to allow SCAN to log its record and continue on. The rest of the code (W) checks for end of file indications and returns when printing is finished.

The INITMOD Module

Last in order (but first in execution) is the INIT procedure. It is called from the TIMER task, which is the highest-priority task in the system (and thus, will be the first to execute after start-up). INIT's role in life is to call FQ0GO (X) to initialize the FORTRAN I/O system, send one message to each of the lock exchanges (Y) , and initialize the operator alarm panel (Z) . The call to FQ0GO is a requirement for an RMX/80 system in which any FORTRAN-80 code that makes use of the iSBC 801 package is to be executed. The call must be made prior to the execution of any FORTRAN-80 I/O or math instructions. Also, the call to FQ0GO should only be made *once.*

```
DATE     TIME     PH   VOLUME     TEMP     DISSOLVED   TOTAL    ORGANIC
                                            OXYGEN     CARBON   CARBON
                      (CU.M)      (C)       (MG/ML)    (MG/ML)  (MG/ML)
9/19/78  8: 5: 0  6.1  2012.32   25.4000    12.3400    76.9800   34.0870
9/19/78  8:10: 0  6.2  2614.00   25.4000    12.5400    88.2340   40.4933

 SUSPENDED  PHOSPHATE  INFLUENT  EFFLUENT  TURBID  AIR DIS  MIX  INF
  SOLIDS      CONC       FLOW      FLOW
  (MG/ML)    (MG/ML)   (MG/ML)   (MG/ML)     %
   16.0987   56.9800   112.090    0.000   74.56  ON OFF    ON   ON
   19.3943   61.4300   119.340    0.000   86.43  ON OFF    ON   ON
```

Figure 19. Sample Output

SYSTEM GENERATION

Configuration Module

Now that all of the code for the individual tasks is written, it is time to generate the tables that give the RMX/80 Executive the information it needs to configure all of the tasks and exchanges. Assembly language macros are included in the RMX/80 product to help make building the configuration module a little easier. After the counters have been initialized, the STD macro is invoked several times to define Static Task Descriptors for the tasks in the system. Of special note are the last two entries (AA) . Any task that uses the FORTRAN I/O system must allocate approximately 800 bytes of stack. This extra stack space is needed to save information on the

current I/O operations. Also, any task performing floating point calculations with the software package needs to append an extra 18 bytes to its Task Descriptor as a workspace area. If the iSBC 310 drivers are used this need be only 13 bytes long. This last field is defined by passing a value of 13 or 18 to the optional parameter, TDXTRA, in the STD macro. The routines in the FORTRAN-80 Run-Time Package require one exchange, FQ0LOK, which is allocated using the XCH macro (BB) , and added to the Initial Exchange Table by the PUBXCH macro (CC) .

Controller Addressable Memory Module

The CAMMOD module (DD) allocates the blocks of memory needed by the RMX/80 Disk File System. Specific details on the contents of this module can be found in the *RMX/80 User's Guide.*

LINK

Figure 20 shows the ISIS-II LINK command used to bind all of the individual modules together with the RMX/80 libraries needed to implement this application. The FORTRAN-80 I/O interface routines are found in the library F80RMX.LIB which is part of the iSBC 801 package. the library FPSFTX.LIB contains the software floating point package. If it is desired to accelerate the execution of the mathematical operations in this system, the iSBC 310 board can be included and the library changed to FPHRDX.LIB for iSBC 80/20, 80/20-4, and 80/30 systems or FPHX10.LIB for iSBC 80/10 and 80/10A systems.

The RMX/80 extensions included are the Disk File System, the Analog Handlers, and the Minimal Terminal Handler.

LOCATE

After the Link has been finished, the command shown in Figure 21 is used to invoke the ISIS-II LOCATE program. The ORDER statement sets the proper order for all of the different segments and common blocks. The common blocks themselves are allocated as fixed blocks of memory to make possible their shared usage by PL/M routines using the AT attribute. This mechanism is discussed in greater detail in AP-44, "How to use FORTRAN With Other Intel Languages".

VII. SUMMARY

The purpose of this application note has been to describe the design process used to decide what operating system support to use, what language to code programs in, what hardware to use and what type of I/O to use to solve a given application problem. The specific application examples presented have keyed on the use of the FORTRAN-80 language.

The lesson that has been learned is that proper design techniques result in the use of the right tool for every job. With a complete set of programming languages, each optimized for a specific use, a powerful real-time executive, and a complete line of flexible hardware products, complicated applications become easy to solve.

```
LINK :F0:RMX830.LIB(START), &
  :F1:X2CFG.OBJ, &
  :F1:RPTMOD.OBJ, &
  :F1:FRTMOD.LIB, &
  :F1:INITMD.OBJ, &
  :F0:F80RUN.LIB, &
  :F0:F80RMX.LIB, &
  :F0:FPEF.LIB, &
  :F0:FPSFTX.LIB, &
  :F0:SYSTEM.LIB, &
  :F0:DFSDIR.LIB(DIRECTORY,DELETE,RENAME,SEEK), &
  :F0:DIO830.LIB, &
  :F0:DFSUNR.LIB, &
  :F1:CAM.OBJ, &
  :F1:PLMMOD.LIB, &
  :F0:AIHDLR.LIB, &
  :F0:AOHDLR.LIB, &
  :F0:MTI830.LIB, &
  :F0:MTO830.LIB, &
  :F0:RMX830.LIB, &
  :F0:UNRSLV.LIB, &
  :F0:PLM80.LIB TO :F1:SEWAGE.LK0 PRINT(:F1:SEWAGE.LNK) MAP
```

Figure 20. LINK Command for Sewage Treatment Example

```
LOCATE :F1:SEWAGE.LK0 PRINT(:F1:SEWAGE.LOC) MAP &
  CODE(0) STACKSIZE(0) LINES SYMBOLS PUBLICS &
  ORDER(CODE DATA /LSTREC/ /STATUS/ /SETPNT/ /MIN5/) /STATUS/(FFA5H) &
  /SETPNT/(FFDEH) /MIN5/(FFEEH) /LSTREC/(FFA3H)
```

Figure 21. LOCATE Command for Sewage Treatment Example

APPENDIX A
CODE LISTINGS

```
ASM80 :F1:DRIVRS.M80 DEBUG PAGEWIDTH(78) PRINT(:F5:DRIVRS.LST)

ISIS-II 8080/8085 MACRO ASSEMBLER, V2.0        DRIVRS   PAGE    1

 LOC  OBJ          SEQ          SOURCE STATEMENT

                     1 NAME    DRIVRS
                     2 ;
                     3 ;+++++++++++++++++++++++++++++++++++++++++++++++++++++++
                     4 ;
                     5 ;       CONSOLE I/O ROUTINES FOR FORTRAN-iSBC SYSTEM.
                     6 ;       START INITIALIZES THE HARDWARE AND CALLS THE
                     7 ;       FORTRAN ROUTINE MAINLN. BUFOUT ACCEPTS TWO
                     8 ;       PARAMETERS FROM THE CALLING FORTRAN ROUTINE
                     9 ;       (ACTUALLY ONE FROM THE ROUTINE SINCE PASSING
                    10 ;       A STRING ARGUMENT FROM FORTRAN RESULTS
                    11 ;       IN THE ADDRESS AND LENGTH OF THE STRING BEING
                    12 ;       SENT) AND OUTPUTS THE STRING TO THE USART
                    13 ;       ON THE 80/20.  BUFIN TAKES THE SAME TWO
                    14 ;       ARGUMENTS AND FILLS IN THE BUFFER WITH
                    15 ;       CHARACTERS UNTIL <CR> IS ENCOUNTERED. LINE
                    16 ;       EDITING IS PROVIDED TO THE EXTENT THAT
                    17 ;       RUBOUT DELETES A CHARACTER AND ECHOES IT,
                    18 ;       CONTROL-X DELETES THE BUFFER AND STARTS OVER,
                    19 ;       AND CONTROL-R PRINTS THE BUFFER CONTENTS.
                    20 ;       BUFOUT CALLS THE ROUTINE CHKIO TO DETERMINE
                    21 ;       IF A CNTL-S HAS BEEN ENTERED TO CAUSE A PAUSE
                    22 ;       IN THE OUTPUT. IF ENCOUNTERED THE ROUTINE
                    23 ;       WAITS UNTIL A MATCHING CNTL-Q IS ENTERED.
                    24 ;
                    25 ;+++++++++++++++++++++++++++++++++++++++++++++++++++++++
000D                26 CR      EQU     0DH     ;ASCII CODE FOR CARRIAGE RET.
000A                27 LF      EQU     0AH     ;ASCII CODE FOR LINE FEED
001B                28 ESC     EQU     1BH     ;ASCII CODE FOR ESCAPE
0018                29 CNTLX   EQU     18H     ;ASCII CODE FOR CONTROL-X
007F                30 RUBOUT  EQU     07FH    ;ASCII CODE FOR RUBOUT
0008                31 BS      EQU     08H     ;ASCII CODE FOR BACKSPACE
0013                32 CNTLS   EQU     13H     ;ASCII CODE FOR CONTROL-S
0011                33 CNTLQ   EQU     11H     ;ASCII CODE FOR CONTROL-Q
0007                34 BELL    EQU     07H     ;ASCII CODE FOR BELL
0012                35 CNTLR   EQU     12H     ;ASCII CODE FOR CONTROL-R
00ED                36 CSTS    EQU     0EDH    ;USART COMMAND/STATUS PORT ADD
00EC                37 CDATA   EQU     0ECH    ;USART DATA PORT ADDRESS
0001                38 TXRDY   EQU     01H     ;MASK FOR TRANSMITTER READY
0002                39 RXRDY   EQU     02H     ;MASK FOR RECEIVER READY
0040                40 RESET   EQU     40H     ;USART RESET COMMAND
004E                41 USMODE  EQU     4EH     ;USART MODE WORD
0027                42 USCMND  EQU     27H     ;USART COMMAND WORD
00B6                43 TIMCMD  EQU     0B6H    ;BAUD RATE CNTR COMMAND WORD
0092                44 CMD55   EQU     92H     ;8255 COMMAND WORD
00DE                45 CNTR2   EQU     0DEH    ;BAUD RATE CNTR PORT ADDRESS
00DF                46 TIMCP   EQU     0DFH    ;TIMER CONTROL PORT ADDRESS
00EB                47 PR8255  EQU     0EBH    ;8255 COMMAND PORT ADDRESS
0080                48 STKSIZ  EQU     128     ;STACK SIZE
00E0                49 BDFCTR  EQU     224     ;BAUD RATE FACTOR(COUNT VALUE)
                    50 ;
                    51 ;       ALLOCATE STACK
                    52 ;

 LOC  OBJ          SEQ          SOURCE STATEMENT

                    53         DSEG
0080                54 FRTSTK: DS      STKSIZ
                    55 ;
                    56 ;       LOCAL DATA STORAGE
                    57 ;
0002                58 BUFPTR: DS      2       ;BUFFER POINTER STORAGE
                    59         CSEG
                    60 ;
                    61 ;       START--STARTUP ROUTINE PROGRAMS THE USART
                    62 ;              AND TIMER THEN CALLS THE FORTRAN
                    63 ;              ROUTINE. IF THE FORTRAN ROUTINE
                    64 ;              RETURNS START SIMPLY STARTS OVER.
                    65 ;
                    66         EXTRN   MAINLN
0000 317F00    D    67 START:  LXI     SP,FRTSTK+STKSIZ-1 ;SET STACK POINTER
0003 AF             68         XRA     A       ;ZERO ACCUMULATOR
0004 D3ED           69         OUT     CSTS    ;BRING USART TO KNOWN STATE
0006 D3ED           70         OUT     CSTS    ;BY SENDING FOUR NULLS
0008 D3ED           71         OUT     CSTS    ;
000A D3ED           72    (A)  OUT     CSTS    ;
000C 3E40           73         MVI     A,RESET ;RESET USART
000E D3ED           74         OUT     CSTS    ;
0010 3E4E           75         MVI     A,USMODE ;SEND USART MODE WORD
0012 D3ED           76         OUT     CSTS    ;
0014 3E27           77         MVI     A,USCMND ;SEND USART COMMAND
```

```
0016 D3ED          78          OUT     CSTS    ;
0018 3EB6          79          MVI     A,TIMCMD ;SEND COMMAND WORD
001A D3DF          80          OUT     TIMCP   ;
001C 3EE0          81          MVI     A,LOW(BDFCTR) ;SEND LOW ORDER BYTE
001E D3DE          82          OUT     CNTR2   ;OF COUNTER VALUE
0020 3E00          83          MVI     A,HIGH(BDFCTR) ;SEND HIGH BYTE OF
0022 D3DE          84          OUT     CNTR2   ;COUNTER VALUE
0024 3E92          85          MVI     A,CMD55 ;8255 COMMAND WORD
0026 D3EB          86          OUT     PR8255  ;PROGRAM 8255
0028 CD0000    E   87          CALL    MAINLN  ;CALL FORTRAN ROUTINE
002B C30000    C   88          JMP     START   ;IF ROUTINE RETURNS START OVER
                   89 ;
                   90 ;        BUFIN--FILLS BUFFER WITH INPUT FROM TERMINAL
                   91 ;
                   92          PUBLIC  BUFIN
                   93 BUFIN:
002E E5            94          PUSH    H       ;SAVE HL PAIR
002F F5            95          PUSH    PSW     ;SAVE PSW
0030 C5            96          PUSH    B       ;SAVE BC
0031 60            97          MOV     H,B     ;GET BUFFER POINTER TO HL
0032 69            98          MOV     L,C     ;
0033 220000    D   99          SHLD    BUFPTR  ;SAVE IT
0036 1600          100         MVI     D,0     ;ZERO TO # CHARACTERS COUNTER
                   101                         ;NOTE: STRING LENGTH <=255
0038 D5            102         PUSH    D       ;SAVE COUNTERS
                   103 GETCHR:
0039 CDE200    C   104         CALL    CI      ;GET CHARACTER
003C FE7F          105         CPI     RUBOUT  ;RUBOUT?
003E C24700    C   106         JNZ     BUF05   ;NO,CONTINUE
0041 CD9000    C   107         CALL    DLTCHR  ;YES,DELETE LAST CHARACTER

LOC  OBJ           SEQ          SOURCE STATEMENT

0044 C33900    C   108         JMP     GETCHR  ;GET NEW ONE
                   109 BUF05:
0047 FE18          110         CPI     CNTLX   ;CONTROL-X?
0049 CAA200    C   111         JZ      DLTLIN  ;YES,DELETE BUFFER
004C FE12          112         CPI     CNTLR   ;CONTROL-R?
004E CAF900    C   113         JZ      PRTBUF  ;YES,PRINT BUFFER
0051 1D            114         DCR     E       ;DECREMENT SPACE LEFT COUNTER
0052 C26300    C   115         JNZ     BUF10   ;CONTINUE IF COUNTER > 0
0055 FE0D          116         CPI     CR      ;IF THIS END OF LINE ALL IS OK
0057 CA6300    C   117         JZ      BUF10
005A 1C            118         INR     E       ;BRING COUNTER BACK ONE
005B 0E07          119         MVI     C,BELL  ;NOT OK, ECHO BELL
005D CDB400    C   120         CALL    ECHO    ;
0060 C33900    C   121         JMP     GETCHR  ;GET NEW CHARACTER
                   122 BUF10:
0063 4F            123         MOV     C,A     ;MOVE CHARACTER TO C
0064 CDB400    C   124         CALL    ECHO    ;AND ECHO IT
0067 71            125         MOV     M,C     ;STORE IT IN BUFFER
0068 23            126         INX     H       ;INCREMENT BUFFER POINTER
0069 14            127         INR     D       ;INCREMENT # OF CHARS COUNTER
006A 3E0D          128         MVI     A,CR    ;IS IT A NEWLINE CHARACTER
006C B9            129         CMP     C       ;
006D C23900    C   130         JNZ     GETCHR  ;NO,CONTINUE FILLING
0070 D1            131         POP     D       ;YES,RETURN
0071 C1            132         POP     B       ;
0072 F1            133         POP     PSW     ;
0073 E1            134         POP     H       ;
0074 C9            135         RET             ;RETURN
                   136 ;
                   137 ;       BUFOUT ENTRY POINT
                   138 ;
                   139         PUBLIC  BUFOUT
0075 E5            140 BUFOUT: PUSH    H       ;SAVE HL REGISTER PAIR
0076 F5            141         PUSH    PSW     ;SAVE PSW
0077 60            142         MOV     H,B     ;GET STRING POINTER INTO HL
0078 69            143         MOV     L,C     ;
0079 CDCD00    C   144 OUTCHR: CALL    CHKIO   ;CHECK FOR PAUSE(CNTL-S)
007C 4E            145         MOV     C,M     ;GET CHARACTER
007D CDB400    C   146         CALL    ECHO    ;OUTPUT TO TERMINAL
0080 3E0D          147         MVI     A,CR    ;IS IT A <CR>?
0082 B9            148         CMP     C       ;
0083 CA8D00    C   149         JZ      EXITLP  ;YES,EXIT
0086 23            150         INX     H       ;INCREMENT POINTER
0087 1B            151         DCX     D       ;DECREMENT STRING COUNT
0088 7A            152         MOV     A,D     ;GET HI BYTE
0089 B3            153         ORA     E       ;AND WITH LO BYTE
008A C27900    C   154         JNZ     OUTCHR  ;IF STRING COUNT <> 0 CONTINUE
008D F1            155 EXITLP: POP     PSW     ;RESTORE PSW
008E E1            156         POP     H       ;RESTORE HL
008F C9            157         RET             ;ALL THROUGH
                   158 ;
                   159 ;       DLTCHR--DELETES LAST CHAR ENTERED INTO BUFFER
                   160 ;
                   161 DLTCHR:
0090 15            162         DCR     D       ;DECREMENT # OF CHARS COUNTER
```

```
LOC  OBJ          SEQ          SOURCE STATEMENT

0091 F29B00   C    163          JP      DLTC10  ;IF >=0 CONTINUE
0094 14            164          INR     D       ;RUBOUT PAST START OF BUFFER
0095 0E07          165          MVI     C,BELL  ;INCREMENT COUNT,ECHO A BELL
0097 CDB400   C    166          CALL    ECHO    ;
009A C9            167          RET             ;AND RETURN
                   168 DLTC10:
009B 1C            169          INR     E       ;INC. SPACE LEFT INDICATOR
009C 2B            170          DCX     H       ;DECREMENT BUFFER POINTER
009D 4E            171          MOV     C,M     ;ECHO DELETED CHARACTER
009E CDB400   C    172          CALL    ECHO    ;
00A1 C9            173          RET             ;AND RETURN
                   174 ;
                   175 ;       DLTLIN--DELETES LINE BUFFER AND BEGINS REFILL
                   176 ;
                   177 DLTLIN:
00A2 0E23          178          MVI     C,'#'   ;ECHO A '#'
00A4 CDB400   C    179          CALL ECHO
00A7 0E0D          180          MVI     C,CR    ;ECHO A CRLF
00A9 CDB400   C    181          CALL ECHO
00AC 2A8000   D    182          LHLD    BUFPTR  ;GET ORIGINAL POINTER BACK
00AF D1            183          POP     D       ;GET COUNTERS BACK
00B0 D5            184          PUSH    D       ;RESAVE
00B1 C33900   C    185          JMP     GETCHR  ;GET NEW CHARACTERS
                   186 ;
                   187 ;       ECHO--ECHOES CHARACTERS TO THE TERMINAL
                   188 ;
00B4 41            189 ECHO:    MOV     B,C     ;SAVE ARGUMENT
00B5 3E1B          190          MVI     A,ESC   ;SEE IF ECHOING AN
00B7 B8            191          CMP     B       ;ESCAPE CHARACTER
00B8 C2BD00   C    192          JNZ     ECH05   ;NO--BRANCH
00BB 0E24          193          MVI     C,'$'   ;YES,ECHO AS '$'
                   194 ECH05:
00BD CDEE00   C    195          CALL    CO      ;OUTPUT IT
00C0 3E0D          196          MVI     A,CR
00C2 B8            197          CMP     B       ;CHARACTER ECHOED A CR?
00C3 C2CB00   C    198          JNZ     ECH10   ;NO--SPECIAL ACTION NOT NEEDED
00C6 0E0A          199          MVI     C,LF    ;YES--ECHO FREE LINE FEED
00C8 CDEE00   C    200          CALL    CO
                   201 ECH10:
00CB 48            202          MOV     C,B     ;RESTORE ARGUMENT
00CC C9            203          RET
                   204 ;
                   205 ;       CHKIO--CHECKS FOR CNTL-S OPERATION
                   206 ;
00CD DBED          207 CHKIO:   IN      CSTS    ;GET STATUS
00CF E602          208          ANI     RXRDY   ;CHARACTER AVAILABLE?
00D1 C8            209          RZ              ;NO,RETURN
00D2 DBEC          210          IN      CDATA   ;YES,GET CHARACTER
00D4 E67F          211          ANI     7FH     ;STRIP OFF PARITY
00D6 FE13          212          CPI     CNTLS   ;CONTROL-S?
00D8 C0            213          RNZ             ;NO,IGNORE IT
00D9 CDE200   C    214 WAIT4Q:  CALL    CI      ;YES,WAIT FOR A CONTROL-Q
00DC FE11          215          CPI     CNTLQ   ;
00DE C2D900   C    216          JNZ     WAIT4Q  ;
00E1 C9            217          RET             ;GOT IT,RETURN
```

```
LOC  OBJ          SEQ          SOURCE STATEMENT

                   218 ;
                   219 ;       CI--ENTER CHARACTER FROM TERMINAL
                   220 ;
00E2 DBED          221 CI:      IN      CSTS    ;GET STATUS BYTE
00E4 E602          222          ANI     RXRDY   ;CHARACTER AVAILABLE
00E6 CAE200   C    223          JZ      CI      ;NO,LOOP
00E9 DBEC          224          IN      CDATA   ;READY,GET CHARACTER
00EB E67F          225          ANI     07FH    ;STRIP OFF PARITY
00ED C9            226          RET
                   227 ;
                   228 ;       CO--OUTPUT CHARACTER IN C REGISTER TO TERMINAL
                   229 ;
00EE DBED          230 CO:      IN      CSTS    ;GET STATUS BYTE
00F0 E601          231          ANI     TXRDY   ;TRANSMITTER READY?
00F2 CAEE00   C    232          JZ      CO      ;NO,LOOP
00F5 79            233          MOV     A,C     ;YES,MOVE CHARACTER TO ACC.
00F6 D3EC          234          OUT     CDATA   ;SEND TO TERMINAL
00F8 C9            235          RET
                   236 ;
                   237 ;       PRTBUF--PRINTS CURRENT BUFFER(CONTROL-R)
                   238 ;
                   239 PRTBUF:
00F9 0E0D          240          MVI     C,CR    ;ECHO CRLF
00FB CDB400   C    241          CALL    ECHO    ;
00FE E5            242          PUSH    H       ;SAVE CURRENT BUFFER POINTER
```

```
00FF 2A8000   D   243          LHLD    BUFPTR  ;GET POINTER TO BEGINNING
0102 D5           244          PUSH    D       ;SAVE CURRENT COUNTERS
                  245 PRLOOP:
0103 15           246          DCR     D       ;DECREMENT COUNTER
0104 FA0F01   C   247          JM      PREXIT  ;NO MORE CHARACTERS IN BUFFER
0107 4E           248          MOV     C,M     ;GET CHARACTER
0108 CDB400   C   249          CALL    ECHO    ;ECHO IT
010B 23           250          INX     H       ;INCREMENT POINTER
010C C30301   C   251          JMP     PRLOOP  ;LOOP UNTIL ALL CHARS OUTPUT
                  252 PREXIT:
010F D1           253          POP     D       ;RESTORE COUNTERS
0110 E1           254          POP     H       ;RESTORE POINTER
0111 C33900   C   255          JMP     GETCHR  ;GET NEW CHARACTER
                  256          END
```

```
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ISIS-II FORTRAN-80      COMPILATION OF PROGRAM UNIT MAINLN
OBJECT MODULE PLACED IN :F1:MAINLN.OBJ
COMPILER INVOKED BY:  FORT80 :F1:MAINLN.FRT DEBUG DATE(10/12/78) PAGEWIDTH(78)

 1      (D)     SUBROUTINE MAINLN
 2              IMPLICIT LOGICAL (A-Z)
        C
        C-- MAINLINE ROUTINE FOR TEST STAND SOFTWARE. COMMAND LINE IS
        C-- SEARCHED FOR KEYLETTER AND APPROPRIATE ROUTINE IS CALLED.
        C-- ALL UNUSED LETTERS TRAP TO ERROR ROUTINE.
        C                                                       /
        C
 3              CHARACTER LINBUF(80)*1,IMAGE*80
 4              INTEGER INDEX*2,CARRET*1,KEYLTR*1,ERRFLG*2,DUMMY*2
 5              COMMON /LINE/ LINBUF,INDEX,CARRET
 6              EQUIVALENCE (LINBUF,IMAGE)
 7              DATA CARRET /13/
        C
        C-- INITIALIZE SYSTEM
        C
 8      (E)     DUMMY=0
 9              CALL FQFSET(DUMMY,DUMMY)
        C
        C-- WRITE BANNER
        C
10      1       WRITE(IMAGE,10,IOSTAT=ERRFLG,ERR=999) CARRET
11       10     FORMAT('TEST STAND V0.0',A)
   (F)  C
        C-- OUTPUT BUFFER
        C
12              CALL BUFOUT(IMAGE)
        C
        C-- INITIALIZE INDEX POINTER TO START OF LINBUF
        C
13      20      INDEX=1
   (G)  C
        C-- PROMPT OPERATOR
        C
14              WRITE(IMAGE,30,IOSTAT=ERRFLG,ERR=999) CARRET
15       30     FORMAT('COMMAND?',A)
16              CALL BUFOUT(IMAGE)
        C
        C-- GET COMMAND LINE
        C
17 (H)          CALL BUFIN(IMAGE)
        C
        C-- POSITION INDEX TO FIRST NON-BLANK CHARACTER
        C
18 (I)          CALL DBLANK
        C
        C-- CONVERT KEYLETTER TO NORMALIZED INTEGER VALUE IE. 'A'=1
        C
19              KEYLTR=ICHAR(LINBUF(INDEX))-#40H
20 (J)          INDEX=INDEX+1
        C




        C-- CHECK FOR INVALID CHARACTERS
        C
21              IF(KEYLTR.GE.1) THEN
22              IF(KEYLTR.LE.#1AH) THEN
        C
        C-- IF VALID CHARACTER JUMP TO PROPER HANDLING ROUTINE
        C
        C               A   B   C   D   E   F   G   H   I   J   K   L   M   N
23 (K)          GOTO(300,100,100,300,100,100,100,100,100,100,100,100,300,100,
        C        O   P   Q   R   S   T   U   V   W   X   Y   Z
                C100,100,100,100,300,200,100,100,100,100,100,100) KEYLTR
```

```
 24            ENDIF
 25            ENDIF
       C
       C-- IF INVALID OUTPUT ERROR AND GET NEW LINE
       C
 26            WRITE(IMAGE,40,IOSTAT=ERRFLG,ERR=999) CARRET
 27       40   FORMAT('INVALID KEYLTR',A)
 28            CALL BUFOUT(IMAGE)
 29            GOTO 20
       C
       C-- CONTROL BRANCHES TO ONE OF THESE BASED ON KEYLETTER
       C
       C
       C-- STATEMENT LINE 100 IS USED TO TRAP ALL KEYLETTERS NOT USED
       C
 30       100  WRITE(IMAGE,110,IOSTAT=ERRFLG,ERR=999) CARRET
 31       110  FORMAT('NO SUCH TEST',A)
 32            CALL BUFOUT(IMAGE)
 33            GOTO 20
       C
       C-- TRANSITION TEST
       C
 34 (L)    200  CALL TRANST
 35            GOTO 20
       C
       C-- CALCULATOR MODE
       C
 36       300  CALL MATH
 37            GOTO 20
       C
       C-- ERROR HANDLER
       C
 38       999  CALL ERROR(ERRFLG)
 39            GOTO 1
 40            END
```

```
ISIS-II FORTRAN-80      COMPILATION OF PROGRAM UNIT DBLANK
OBJECT MODULE PLACED IN :F1:DBLANK.OBJ
COMPILER INVOKED BY:  FORT80 :F1:DBLANK.FRT DEBUG DATE(10/12/78) PAGEWIDTH(78)
```

```
  1 (M)       SUBROUTINE DBLANK
  2           IMPLICIT LOGICAL (A-Z)
       C
       C-- POSITIONS INDEX TO NEXT NON-BLANK CHARACTER IN LINBUF
       C
  3           INTEGER INDEX*2,CARRET*1,ERRFLG*2
  4           CHARACTER LINBUF(80)*1,IMAGE*80,ENDLIN*1
  5           EQUIVALENCE (LINBUF,IMAGE),(ENDLIN,CARRET)
  6           COMMON /LINE/ LINBUF,INDEX,CARRET
       C
  7        1  IF(LINBUF(INDEX).EQ.ENDLIN) GOTO 2
  8           IF(LINBUF(INDEX).NE.' ') RETURN
  9           INDEX=INDEX+1
 10           IF(INDEX.LE.72) GOTO 1
       C
       C-- IF END OF LINE ASK FOR MORE PARAMETERS
       C
 11        2  WRITE(IMAGE,3,IOSTAT=ERRFLG,ERR=999)  CARRET
 12        3  FORMAT('MISSING PARAMETER,PLEASE ENTER',A)
 13           CALL BUFOUT(IMAGE)
 14           CALL BUFIN(IMAGE)
 15           INDEX=1
 16           GOTO 1
       C
       C-- ERROR HANDLER
       C
 17        999  CALL ERROR(ERRFLG)
 18           RETURN
 19           END
```

```
ISIS-II FORTRAN-80      COMPILATION OF PROGRAM UNIT ERROR
OBJECT MODULE PLACED IN :F1:ERROR.OBJ
COMPILER INVOKED BY:  FORT80 :F1:ERROR.FRT DEBUG DATE(10/12/78) PAGEWIDTH(78)
```

```
  1 (N)       SUBROUTINE ERROR(ERRNUM)
  2           IMPLICIT LOGICAL(A-Z)
       C
       C-- OUTPUT ERROR MESSAGE
       C
```

```
      3           CHARACTER IMAGE*80,LINBUF(80)*1
      4           INTEGER ERRNUM*2,INDEX*2,CARRET*1
      5           EQUIVALENCE (LINBUF,IMAGE)
      6           COMMON /LINE/ LINBUF,INDEX,CARRET
                  C
      7           WRITE(IMAGE,10) ERRNUM,CARRET
      8       10  FORMAT('***ERROR*** #',I4,A)
      9           CALL BUFOUT(IMAGE)
     10           RETURN
     11           END
```

```
ISIS-II FORTRAN-80      COMPILATION OF PROGRAM UNIT MATH
OBJECT MODULE PLACED IN :F1:MATH.OBJ
COMPILER INVOKED BY:  FORT80 :F1:MATH.FRT DEBUG DATE(10/12/78) PAGEWIDTH(78)
```

```
      1           SUBROUTINE MATH
      2           IMPLICIT LOGICAL (A-Z)
                  C
                  C-- IMPLEMENTS CALCULATOR MODE
                  C
      3           INTEGER INDEX*2,CARRET*1,ERRFLG*2
      4           CHARACTER LINBUF(80)*1,IMAGE*80,COMMND*1,SYMBOL*1
      5           REAL OP1,OP2,RESULT
      6           EQUIVALENCE (LINBUF,IMAGE)
      7           COMMON /LINE/ LINBUF,INDEX,CARRET
                  C
                  C-- RESCAN KEYLETTER TO DETERMINE OPERATION
                  C
      8           INDEX=INDEX-1
      9           COMMND=LINBUF(INDEX)
     10           INDEX=INDEX+1
                  C
                  C-- MOVE INDEX TO FIRST OPERAND
                  C
     11           CALL DBLANK
                  C
                  C-- GET IT IN
                  C
     12           CALL CONVRT(OP1)
                  C
                  C-- REPEAT FOR SECOND OPERAND
                  C
     13           CALL DBLANK
     14           CALL CONVRT(OP2)
                  C
                  C-- PERFORM OPERATION
                  C
     15           IF(COMMND.EQ.'M') THEN
     16           RESULT=OP1*OP2
     17           SYMBOL='*'
     18           GOTO 11
     19           ENDIF
                  C
     20           IF(COMMND.EQ.'D') THEN
     21           RESULT=OP1/OP2
     22           SYMBOL='/'
     23           GOTO 11
     24           ENDIF
                  C
     25           IF(COMMND.EQ.'A') THEN
     26           RESULT=OP1+OP2
     27           SYMBOL='+'
     28           GOTO 11
     29           ENDIF
                  C
     30           IF(COMMND.EQ.'S') THEN
     31           RESULT=OP1-OP2
     32           SYMBOL='-'
     33           GOTO 11
     34           ENDIF
                  C
                  C-- OUTPUT RESULTS
                  C
     35       11  WRITE(IMAGE,12,IOSTAT=ERRFLG,ERR=999) OP1,SYMBOL,OP2,RESULT,
                 1CARRET
     36       12  FORMAT(F18.5,1X,A,1X,F18.5,1X,'=',1X,F18.5,A)
     37           CALL BUFOUT(IMAGE)
```

```
 38            RETURN
               C
               C-- ERROR HANDLER
               C
 39        999 CALL ERROR(ERRFLG)
 40            RETURN
 41            END
```

```
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ISIS-II FORTRAN-80      COMPILATION OF PROGRAM UNIT CONVRT
OBJECT MODULE PLACED IN :F1:CONVRT.OBJ
COMPILER INVOKED BY:  FORT80 :F1:CONVRT.FRT DEBUG DATE(10/12/78) PAGEWIDTH(78)


  1       (R) SUBROUTINE CONVRT(VALUE)
  2           IMPLICIT LOGICAL(A-Z)
              C
              C-- INPUTS NEXT PARAMETER IN LINBUF
              C
  3           INTEGER I*1,INDEX*2,TMPIND*1,CARRET*1,ERRFLG*2
  4           REAL VALUE
  5           CHARACTER LINBUF(80)*1,TMPBUF(20)*1,BUFFER*20,ENDLIN*1
  6           EQUIVALENCE (TMPBUF,BUFFER),(ENDLIN,CARRET)
  7           COMMON /LINE/ LINBUF,INDEX,CARRET
              C
              C-- INITIALIZE
              C
  8           DO 21 I=1,19
  9    21     TMPBUF(I)=' '
 10           TMPBUF(20)=ENDLIN
 11           TMPIND=1
              C
              C-- FILL BUFFER UNTIL COMMA OR ENDLINE ENCOUNTERED
              C
 12    22     TMPBUF(TMPIND)=LINBUF(INDEX)
 13           INDEX=INDEX+1
 14           TMPIND=TMPIND+1
 15           IF(LINBUF(INDEX).EQ.',') THEN
 16      (S)  INDEX=INDEX+1
 17           GOTO 23
 18           ENDIF
 19           IF(LINBUF(INDEX).EQ.ENDLIN) GOTO 23
 20           GOTO 22
              C
              C-- READ UNDER FORMAT CONTROL
              C
 21    23     READ(BUFFER,24,IOSTAT=ERRFLG,ERR=999) VALUE
 22   (T)     FORMAT(F19.5)
 23           RETURN
              C
              C-- ERROR HANDLER
              C
 24    999    CALL ERROR(ERRFLG)
 25           RETURN
 26           END
```

```
ISIS-II FORTRAN-80      COMPILATION OF PROGRAM UNIT TRANST
OBJECT MODULE PLACED IN :F1:TRANST.OBJ
COMPILER INVOKED BY:  FORT80 :F1:TRANST.FRT DEBUG DATE(10/12/78) PAGEWIDTH(78)


  1           SUBROUTINE TRANST
  2           IMPLICIT LOGICAL (A-Z)
              C
              C-- PERFORM TRANSITION TESTING
              C
  3            REAL START,STOP,STEP,TOL,TEMP,VOLTAG,VCC(20),
             1LOWLVL(20),LOTOHI(20),HILVL(20),HITOLO(20)
              C
  4            INTEGER CARRET*1,ITEMP*2,TSTINP*2,SAMPLE*2,
             1LSTSAM*2,DELTA*2,ERRFLG*2,PNTCNT*1,INDEX*2,I*1
              C
  5            CHARACTER LINBUF(80)*1,IMAGE*80,TEST(20)*6
              C
  6            EQUIVALENCE (LINBUF,IMAGE)
              C
  7            COMMON /LINE/ LINBUF,INDEX,CARRET
              C
              C-- INITIALIZE
              C
```

```
 8            DO 5, I=1,20
 9      5     TEST(I)='PASSED'
10            TSTINP=0
11            PNTCNT=1
              C
              C-- SCAN COMMAND TAIL FOR PARAMETERS
              C
              C      VCC START      STOP      STEP      TOLERANCE
              C
12            CALL DBLANK
13            CALL CONVRT(START)
14            CALL DBLANK
15            CALL CONVRT(STOP)
16            CALL DBLANK
17            CALL CONVRT(STEP)
18            CALL DBLANK
19            CALL CONVRT(TOL)
              C
              C-- IF (STOP-START)/STEP YIELDS MORE THAN 20 STEPS
              C-- OUTPUT MESSAGE AND RETURN
              C
20            IF(IFIX((STOP-START)/STEP).GT.20) THEN
21            WRITE(IMAGE,10,IOSTAT=ERRFLG,ERR=999) CARRET
22      10    FORMAT('TOO MANY POINTS',A)
23            CALL BUFOUT(IMAGE)
24            RETURN
25            ENDIF
              C
              C-- GET TEMPERATURE AND LINEARIZE
              C
26            CALL ADCIN(ITEMP,0)
27      (U)   TEMP=98.63*ALOG(FLOAT(ITEMP))+13.56
```

```
              C
              C-- OUTPUT HEADER
              C
28            WRITE(IMAGE,20,IOSTAT=ERRFLG,ERR=999) TOL,TEMP,CARRET,CARRET
29      20    FORMAT('TRANSITION TEST  TOLERANCE=',F5.1,
             1'% AMBIENT TEMPERATURE = ',F6.2,' DEGREES C',A,A)
30            CALL BUFOUT(IMAGE)
31            WRITE(IMAGE,30,IOSTAT=ERRFLG,ERR=999) CARRET,CARRET
32      30    FORMAT('    VCC    HIGH TRANS  LOW TRANS  HIGH   LOW    TEST',
             1A,A)
33            CALL BUFOUT(IMAGE)
              C
              C-- BEGIN TEST; OUTPUT STARTING VCC VALUE
              C
34            VOLTAG=START
35      40    VCC(PNTCNT)=VOLTAG
36            CALL DACOUT(IFIX(VOLTAG*409.6),0)
              C
              C-- OUTPUT ZERO VOLTS TO TEST INPUT
              C
37      (V)   CALL DACOUT(TSTINP,1)
              C
              C-- GET ONE SAMPLE
              C
38            CALL ADCIN(SAMPLE,1)
              C
              C-- MAKE IT THE LAST SAMPLE AND ALSO STORE IT
              C
39            LSTSAM=SAMPLE
40            LOWLVL(PNTCNT)=FLOAT(SAMPLE)*409.6
              C
              C-- BEGIN LOOP LOOKING FOR LOW TO HIGH TRANSITION
              C
41      50    TSTINP=TSTINP+1
42            CALL DACOUT(TSTINP,1)
              C
              C-- GET SAMPLE
              C
43            CALL ADCIN(SAMPLE,1)
44            DELTA=SAMPLE-LSTSAM
              C
              C-- SEE IF TRANSITION;DELTA .GT. 2.2 VOLTS
              C
45            IF(DELTA.LT.901) THEN
46            LSTSAM=SAMPLE
              C
              C-- NO TRANSITION; IF TSTINP NOW UP TO 5.5V AND NO TRANSITION
              C-- OUTPUT MESSAGE INDICATING DEAD PART AND RETURN
              C
47            IF(TSTINP.GE.2251) THEN
```

```
48                WRITE(IMAGE,60,IOSTAT=ERRFLG,ERR=999) CARRET
49 (W) 90         FORMAT('DEAD PART, NO TRANSITION',A)
50                CALL BUFOUT(IMAGE)
51                RETURN
52                ENDIF
                C
                C-- CONTINUE LOOP
                C
53                GOTO 50
54                ENDIF
                C
                C-- TRANSITION; ASSIGN ARRAY ELEMENT
                C
55                LOTOHI(PNTCNT)=FLOAT(TSTINP)/409.6
                C
                C-- CHECK TOLERANCE
                C
56                IF((LOTOHI(PNTCNT).GE.(.8-(TOL/100.*.8))).AND.
                 1(LOTOHI(PNTCNT).LE.(.8+(TOL/100.*.8)))) GOTO 70
                C
                C-- TEST FAILED
                C
57                TEST(PNTCNT)='FAILED'
                C
                C-- BEGIN HIGH TO LOW TEST
                C
                C
                C-- OUTPUT 5.0 VOLTS
                C
58              70    TSTINP=2048
59                    CALL DACOUT(TSTINP,1)
                C
                C-- GET SAMPLE
                C
60                    CALL ADCIN(SAMPLE)
                C
                C-- MAKE IT LAST SAMPLE AND ALSO STORE IT
                C
61                    LSTSAM=SAMPLE
62                    HILVL(PNTCNT)=FLOAT(SAMPLE)*409.6
                C
                C-- BEGIN LOOP LOOKING FOR HIGH TO LOW TRANSITION
                C
63              80    TSTINP=TSTINP-1
64                    CALL DACOUT(TSTINP,1)
                C
                C-- GET SAMPLE
                C
65                    CALL ADCIN(SAMPLE,1)
66                    DELTA=LSTSAM-SAMPLE
                C
                C-- SEE IF TRANSITION; DELTA .GT. 2.2 VOLTS
                C
67                    IF(DELTA.LT.901) THEN
68                    LSTSAM=SAMPLE
                C
                C-- NO TRANSITION; CHECK TO SEE IF VOLTAGE DOWN TO ZERO
                C
69                    IF(TSTINP.LE.0) THEN
                C
                C-- YES; OUTPUT DEAD PART MESSAGE
                C
70                    WRITE(IMAGE,60,IOSTAT=ERRFLG,ERR=999) CARRET
71                    CALL BUFOUT(IMAGE)

72                    RETURN
73                    ENDIF
                C
                C-- CONTINUE LOOP
                C
74                    GOTO 80
75                    ENDIF
                C
                C-- TRANSITION; ASSIGN ARRAY ELEMENT
                C
76                    HITOLO(PNTCNT)=FLOAT(TSTINP)*409.6
                C
                C-- CHECK TOLERANCE
                C
77                    IF((HITOLO(PNTCNT).GE.(3.5-(TOL/100.*3.5))).AND.
                     1(HITOLO(PNTCNT).LE.(3.5+(TOL/100.*3.5)))) GOTO 90
                C
                C-- TEST FAILED
                C
```

```
78            TEST(PNTCNT)='FAILED'
              C
              C-- INCREMENT VCC AND IF NOT .GT. STOP CONTINUE
              C
79        90    VOLTAG=VOLTAG+STEP
80            IF(VOLTAG.LE.STOP) THEN
81            PNTCNT=PNTCNT+1
82            TSTINP=0
83            GOTO 40
84            ENDIF
              C
              C-- TEST COMPLETE; OUTPUT RESULTS
              C
85            DO 110,I=1,PNTCNT
86            WRITE(IMAGE,100,IOSTAT=ERRFLG,ERR=999) VCC(I),
             1LOTOHI(I),HITOLO(I),HILVL(I),LOWLVL(I),TEST(I),CARRET
87        100   FORMAT(3X,F5.2,3X,F6.2,6X,F6.2,3X,F6.2,1X,F6.2,2X,6A,A)
88        110   CALL BUFOUT(IMAGE)
89            RETURN
              C
              C-- ERROR HANDLER
              C
90        999   CALL ERROR(ERRFLG)
91            RETURN
92            END
```

```
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ISIS-II FORTRAN-80      COMPILATION OF PROGRAM UNIT ADCIN
OBJECT MODULE PLACED IN :F1:ADCIN.OBJ
COMPILER INVOKED BY:  FORT80 :F1:ADCIN.FRT DEBUG DATE(10/12/78) PAGEWIDTH(78)

  1  (X)       SUBROUTINE ADCIN(VALUE,CHAN)
               C
               C-- ROUTINE TO INPUT SINGLE VALUE FROM A/D CONVERTER CHANNEL
               C-- GIVEN AND RETURN IT IN VALUE FIELD.
               C
  2            INTEGER*2 VALUE
  3            INTEGER*1 CHAN
  4    $INCLUDE(:F1:ADCDAC.DEC)
     =  C
     =  C-- DEFINITIONS OF ISBC 732 REGISTERS
     =  C
     =  C
     =  C-- COMMAND STATUS REGISTER
     =  C
  5  =         INTEGER*1 CMDSTS
     =  C
     =  C-- MUX ADDRESS REGISTER
     =  C
  6  =         INTEGER*1 MUXADR
     =  C
     =  C-- LAST CHANNEL REGISTER
     =  C
  7  =         INTEGER*1 LSTCHN
     =  C
     =  C-- CLEAR INTERRUPT COMMAND WORD
     =  C
  8  =         INTEGER*1 CLRINT
     =  C
     =  C-- ADC DATA REGISTER
     =  C
  9  =         INTEGER*2 ADCDAT
     =  C
     =  C-- DAC 0 DATA REGISTER
     =  C
 10  =         INTEGER*2 DAC0
     =  C
     =  C-- DAC 1 DATA REGISTER
     =  C
 11  =         INTEGER*2 DAC1
     =  C
     =  C-- SET UP COMMON BLOCK
     =  C
 12  =         COMMON /ADC/ CMDSTS,MUXADR,LSTCHN,CLRINT,ADCDAT,DAC0,DAC1
               C
               C-- SET UP CHANNEL ADDRESS
               C
 13            MUXADR=CHAN
               C
               C-- START CONVERSION
               C
 14            CMDSTS=#1H
```

```
        C
        C-- WAIT FOR END OF CONVERSION
        C
15       1    IF((CMDSTS.AND.#80H).NE.#80H) GOTO 1
        C
        C-- GET DATA IN
        C
16           VALUE=ADCDAT
        C
        C-- RIGHT JUSTIFY AND CONVERT TO COUNTS
        C
17           VALUE=VALUE/16
18           IF(VALUE.LT.0) VALUE=VALUE+4096+1
19           RETURN
20           END
```

```
ISIS-II FORTRAN-80      COMPILATION OF PROGRAM UNIT DACOUT
OBJECT MODULE PLACED IN :F1:DACOUT.OBJ
COMPILER INVOKED BY:  FORT80 :F1:DACOUT.FRT DEBUG DATE(10/12/78) PAGEWIDTH(78)
```

```
 1 (Y)       SUBROUTINE DACOUT(VALUE,CHAN)
        C
        C-- OUTPUTS VALUE TO D/A CONVERTER
        C
 2           INTEGER*2 VALUE,CHAN
 3      $INCLUDE(:F1:ADCDAC.DEC)
    =   C
    =   C-- DEFINITIONS OF ISBC 732 REGISTERS
    =   C
    =   C
    =   C-- COMMAND STATUS REGISTER
    =   C
 4  =           INTEGER*1 CMDSTS
    =   C
    =   C-- MUX ADDRESS REGISTER
    =   C
 5  =           INTEGER*1 MUXADR
    =   C
    =   C-- LAST CHANNEL REGISTER
    =   C
 6  =           INTEGER*1 LSTCHN
    =   C
    =   C-- CLEAR INTERRUPT COMMAND WORD
    =   C
 7  =           INTEGER*1 CLRINT
    =   C
    =   C-- ADC DATA REGISTER
    =   C
 8  =           INTEGER*2 ADCDAT
    =   C
    =   C-- DAC 0 DATA REGISTER
    =   C
 9  =           INTEGER*2 DAC0
    =   C
    =   C-- DAC 1 DATA REGISTER
    =   C
10  =           INTEGER*2 DAC1
    =   C
    =   C-- SET UP COMMON BLOCK
    =   C
11  =           COMMON /ADC/ CMDSTS,MUXADR,LSTCHN,CLRINT,ADCDAT,DAC0,DAC1
        C
        C-- OUTPUT VALUE TO PROPER CHANNEL
        C-- AFTER SHIFTING INTO HIGH ORDER 12 BITS
        C
12           IF(VALUE.LT.0) VALUE=VALUE+4096+1
13           VALUE=VALUE*16
14           IF(CHAN.EQ.0) DAC0=VALUE
15           IF(CHAN.EQ.1) DAC1=VALUE
16           RETURN
17           END
```

APPENDIX B
CODE LISTINGS

```
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ISIS-II PL/M-80 V3.1 COMPILATION OF MODULE SEMAPHORES
OBJECT MODULE PLACED IN :F1:SEMMOD.OBJ
COMPILER INVOKED BY:  plm80 :F1:SEMMOD.plm DEBUG DATE(10/12/78) PAGEWIDTH(78)


   1          SEMAPHORES:
                  DO;

              /*************************************************************

                  Contains LOCK and UNLOCK procedures for
                  manipulating semaphores. Called by FORTRAN
                  routines with one parameter; the address of
                  the index of the semaphore to be operated on.

              *************************************************************/

              $nolist

  17   1      DECLARE (stslok,setlok,dsklok) (10) BYTE PUBLIC;
  18   1      DECLARE semaphore(3) ADDRESS PUBLIC DATA(
                  .stslok,
                  .setlok,
                  .dsklok);
  19   1      DECLARE token (3) STRUCTURE(
                  link ADDRESS,
                  length ADDRESS,
                  type ADDRESS) PUBLIC;

  20   1      LOCK: PROCEDURE(sema$number$ptr) REENTRANT PUBLIC;

  21   2      DECLARE sema$number$ptr ADDRESS;
  22   2      DECLARE sema$number BASED sema$number$ptr BYTE;
  23   2      DECLARE msg$ptr ADDRESS;

  24   2          msg$ptr=RQWAIT(semaphore(sema$number),0);
  25   2      (A) RETURN;
  26   2          END;

  27   1      UNLOCK: PROCEDURE(sema$number$ptr) REENTRANT PUBLIC;

  28   2      DECLARE sema$number$ptr ADDRESS;
  29   2      DECLARE sema$number BASED sema$number$ptr BYTE;

  30   2          CALL RQSEND(semaphore(sema$number),.token(sema$number));
  31   2      (B) RETURN;
  32   2          END;
  33   1      END SEMAPHORES;
```

```
ISIS-II FORTRAN-80      COMPILATION OF PROGRAM UNIT STSINP
OBJECT MODULE PLACED IN :F1:STSMOD.OBJ
COMPILER INVOKED BY:  FORT80 :F1:STSMOD.FRT DEBUG DATE(10/12/78) PAGEWIDTH(78)


   1      (C)     SUBROUTINE STSINP
   2              IMPLICIT LOGICAL (A-Z)
          C
          C-- TASK CODE FOR STATUS INPUT TASK. UPDATES STATUS COMMON
          C-- BLOCK WITH ANALOG AND DIGITAL DATA VALUES. ALSO DOES
          C-- ANALOG COUNT TO ENGINEERING UNIT CONVERSIONS.
          C
   3              CHARACTER SMPLBF*22,CLOCK*12
   4              INTEGER*2 SAMPLS(11),DUMMY
   5              REAL ANDATA(11)
   6              EQUIVALENCE (SMPLBF,SAMPLS)
   7              INTEGER*1 DIGDAT,I
   8              COMMON /STATUS/ ANDATA,DIGDAT,CLOCK
          C
          C-- INITIALIZE FLOATING POINT LIBRARIES
          C
   9  (D)         DUMMY=0
  10              CALL FQFSET(DUMMY,DUMMY)
          C
          C-- CALL INITIALIZATION ROUTINE
          C
  11  (E)         CALL INITIO
          C
          C-- CALL ROUTINE TO INPUT SAMPLES
          C
  12      10      CALL SMPLIN(SMPLBF)
      (F) C
          C-- SHIFT SAMPLS TO RIGHT JUSTIFY
          C
```

```
13 (G)          DO 50 I=1,11
14              SAMPLS(I)=SAMPLS(I)/16
15        50    IF(SAMPLS(I).LT.0) SAMPLS(I)=SAMPLS(I)+4096+1
                C
                C-- WAIT FOR ACCESS TO STATUS COMMON BLOCK FOR UPDATE
                C-- THEN CONVERT SAMPLES TO ENGINEERING UNITS AND STORE
                C
16              CALL LOCK(0)
17              ANDATA(1)=FLOAT(SAMPLS(1))
18              ANDATA(2)=ALOG10(FLOAT(SAMPLS)*2.34)-365.98
19              ANDATA(3)=ALOG10(FLOAT(SAMPLS(3)/13.9)-21.53
20              ANDATA(4)=13.23*FLOAT(SAMPLS(4))-20.78
21              ANDATA(5)=FLOAT(SAMPLS(5))
22        (H)   ANDATA(6)=FLOAT(SAMPLS(6))/14.225
23              ANDATA(7)=FLOAT(SAMPLS(7))
24              ANDATA(8)=ALOG(FLOAT(SAMPLS(8)/23.98)+235.98
25              ANDATA(9)=FLOAT(SAMPLS(9))
26              ANDATA(10)=FLOAT(SAMPLS(10))
27              ANDATA(11)=(FLOAT(SAMPLS(11))-119.34)/5.734
28              CALL INPUT(#0E8H,DIGDAT)
                C
                C-- RELEASE LOCK ON STATUS COMMON BLOCK
                C
29              CALL UNLOCK(0)
                C
                C-- DELAY FOR 1 SECOND THEN SCAN AGAIN
                C
30        (I)   CALL WAIT
                C
                C-- LOOP BACK
                C
31              GOTO 10
32              END
```

```
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ISIS-II PL/M-80 V3.1 COMPILATION OF MODULE ANALOGIOMOD
OBJECT MODULE PLACED IN :F1:aiomod.OBJ
COMPILER INVOKED BY:  plm80 :F1:aiomod.plm DEBUG DATE(10/12/78) PAGEWIDTH(78)


   1          ANALOG$IO$MOD:
                  DO;

              /*************************************************************

                  Inputs analog samples into buffer provided as
                  calling parameter.

              *************************************************************/

              $nolist

24    1   (J) DECLARE AN$RESP (10) BYTE PUBLIC;
25    1       DECLARE ANALOG$REQUEST$MESSAGE ai$msg;

26    1       INITIO: PROCEDURE PUBLIC;

              /* initializes mesage to be used for analog samples */

27    2       ANALOG$REQUEST$MESSAGE.length=size(ANALOG$REQUEST$MESSAGE);
28    2       ANALOG$REQUEST$MESSAGE.type=AISQS;
29    2   (K) ANALOG$REQUEST$MESSAGE.response$exchange=.AN$RESP;
30    2       ANALOG$REQUEST$MESSAGE.base$ptr=0FFF0H;
31    2       ANALOG$REQUEST$MESSAGE.channel$gain=0;

32    2       RETURN;
33    2       END; /* of INIT$IO */

34    1       SMPL$IN: PROCEDURE(sample$buffer$ptr,buf$size) PUBLIC;

              /* inputs buf$size/2 analog word samples */

35    2       DECLARE (sample$buffer$ptr,buf$size,dummy) ADDRESS;
36    2       DECLARE sample$buffer BASED sample$buffer$ptr (1) BYTE;

37    2           ANALOG$REQUEST$MESSAGE.array$ptr=sample$buffer$ptr;
38    2           ANALOG$REQUEST$MESSAGE.count=buf$size/2;

39    2   (L)     CALL RQSEND(.RQAIEX,.ANALOG$REQUEST$MESSAGE);
40    2           dummy=RQWAIT(.AN$RESP,0);
```

```
 41   2          RETURN;
 42   2          END; /* of SMPLSIN */

 43   1      END ANALOG$IO$MOD;
```

```
ISIS-II FORTRAN-80      COMPILATION OF PROGRAM UNIT SCAN
OBJECT MODULE PLACED IN :F1:SCANMD.OBJ
COMPILER INVOKED BY:  FORT80 :F1:SCANMD.FRT DEBUG DATE(10/12/78) PAGEWIDTH(78)
```

```
  1           SUBROUTINE SCAN
              C
              C-- CODE FOR SCAN TASK THAT COMPARES STATUS VALUES WITH
              C-- SETPOINTS AND SETS OPERATOR ALARMS ACCORDINGLY. ALSO
              C-- LOGS DISK RECORD OF STATUS WHEN MIN5UP FLAG IS TRUE.
              C
  2           $INCLUDE(:F1:EQUIV.DEC)
  3   =       CHARACTER BUFFER*57,PARAMS(57)*1
  4   =       REAL PH,VOLUME,TEMP,DISOXY,TOTCAR,ORGCAR
  5   =       REAL SUSSOL,PHOSFT,INFLOW,EFLFLO,TURBID
  6   =       INTEGER*1 DIGDAT
  7   =       INTEGER*2 MONTH,DAY,YEAR,HOUR,MINUTE,SECOND
  8   =       EQUIVALENCE (PARAMS,BUFFER)
  9   =       EQUIVALENCE (PARAMS,PH)
 10   =       EQUIVALENCE (PARAMS(5),VOLUME)
 11   =       EQUIVALENCE (PARAMS(9),TEMP)
 12   =       EQUIVALENCE (PARAMS(13),DISOXY)
 13   =       EQUIVALENCE (PARAMS(17),TOTCAR)
 14   =       EQUIVALENCE (PARAMS(21),ORGCAR)
 15   =       EQUIVALENCE (PARAMS(25),SUSSOL)
 16   =       EQUIVALENCE (PARAMS(29),PHOSFT)
 17   =  (M)  EQUIVALENCE (PARAMS(33),INFLOW)
 18   =       EQUIVALENCE (PARAMS(37),EFLFLO)
 19   =       EQUIVALENCE (PARAMS(41),TURBID)
 20   =       EQUIVALENCE (PARAMS(45),DIGDAT)
 21   =       EQUIVALENCE (PARAMS(46),MONTH)
 22   =       EQUIVALENCE (PARAMS(48),DAY)
 23   =       EQUIVALENCE (PARAMS(50),YEAR)
 24   =       EQUIVALENCE (PARAMS(52),HOUR)
 25   =       EQUIVALENCE (PARAMS(54),MINUTE)
 26   =       EQUIVALENCE (PARAMS(56),SECOND)
 27           INTEGER*2 ERRFLG,RECNO,DUMMY
 28           REAL SETSOL,SETCAR,SETPHS,SETTRB
 29           INTEGER*1 MIN5UP
 30           COMMON /MIN5/ MIN5UP
 31           COMMON /SETPNT/ SETPHS,SETSOL,SETCAR,SETTRB
 32           COMMON /STATUS/ BUFFER
 33           COMMON /LSTREC/ RECNO
              C
              C-- INITIALIZE RECORD COUNTER
              C
 34           RECNO=1
              C
              C-- INITIALIZE MATH LIBRARIES
              C
 35           DUMMY=0
 36           CALL FQFSET(DUMMY,DUMMY)
              C
              C-- WAIT FOR ACCESS TO STATUS AND SETPOINT COMMON BLOCKS
              C
 37     10    CALL LOCK(0)
```

```
 38           CALL LOCK(1)
              C
              C-- SCAN FOR ALARMS ONLY IF EFFLUENT PUMP IS ON
              C
 39           IF((DIGDAT.AND.#04H).EQ.#04H) THEN
 40           IF(PHOSFT.GT.SETPHS) THEN
 41           CALL OUTPUT(#0EBH,#01H)
 42           ELSE
 43           CALL OUTPUT(#0EBH,#00H)
 44           ENDIF
 45           IF(SUSSOL.GT.SETSOL) THEN
 46      (N)  CALL OUTPUT(#0EBH,#03H)
 47           ELSE
 48           CALL OUTPUT(#0EBH,#02H)
 49           ENDIF
 50           IF(TOTCAR.GT.SETCAR) THEN
 51           CALL OUTPUT(#0EBH,#05H)
 52           ELSE
```

```
53                CALL OUTPUT(#0EBH,#04H)
54                ENDIF
55          (N)   IF(TURBID.GT.SETTRB) THEN
56                CALL OUTPUT(#0EBH,#07H)
57                ELSE
58                CALL OUTPUT(#0EBH,#06H)
59                ENDIF
60                ENDIF
              C
              C-- IF MIN5 TASK HAS SET MIN5UP LOG STATUS ON DISK
              C
61          (O)   IF(MIN5UP.NE.0) THEN
62                MIN5UP=0
              C
              C-- WAIT FOR ACCESS TO DISK
              C
63                CALL LOCK(2)
64                OPEN(3,FILE=':D0:TODAYS.RPT',STATUS='OLD',IOSTAT=ERRFLG,
                  1ERR=9000,ACCESS='DIRECT',RECL=57)
65          (P)   WRITE(3,REC=RECNO,IOSTAT=ERRFLG,ERR=9100) BUFFER
66                RECNO=RECNO+1
67                CLOSE (3,IOSTAT=ERRFLG,ERR=9200)
68                CALL UNLOCK(2)
69                ENDIF
              C
              C-- RELEASE LOCK ON STATUS AND SETPOINT COMMON BLOCKS
              C
70                CALL UNLOCK(1)
71                CALL UNLOCK(0)
              C
              C-- DELAY FOR 1 SECOND THEN SCAN AGAIN
              C
72                CALL WAIT
              C
              C-- LOOP BACK
              C
73                GOTO 10
              C
              C-- ERROR HANDLERS
```

```
          (Q)
              C
74            9000  WRITE(6,9001) ERRFLG
75            9001  FORMAT('OPEN ERROR IN SCAN; #',I4)
76                  GOTO 10
77            9100  WRITE(6,9101) ERRFLG
78            9101  FORMAT('WRITE ERROR IN SCAN; #',I4)
79                  GOTO 10
80            9200  WRITE(6,9201) ERRFLG
81            9201  FORMAT('CLOSE ERROR IN SCAN; #',I4)
82                  GOTO 10
83                  END
```

```
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ISIS-II PL/M-80 V3.1 COMPILATION OF MODULE MIN5MOD
OBJECT MODULE PLACED IN :F1:MIN5MD.OBJ
COMPILER INVOKED BY:  plm80 :F1:MIN5MD.plm DEBUG DATE(10/12/78) PAGEWIDTH(78)


   1          MIN$5$MOD:
                  DO;

              /*************************************************************

                  This module contains the code for TIMER$5 who
                  waits for 5 minutes and sets a flag telling
                  SCAN to log a report on the disk, and for
                  WAIT who waits for 1 second then returns

              *************************************************************/

              $nolist

  19    1       DECLARE min$5$ex (10) BYTE PUBLIC;
  20    1       DECLARE min$5$up BYTE AT(0FFEEH);
  21    1       DECLARE time$out$msg$ptr ADDRESS;
  22    1       DECLARE five$minute$delay$count LITERALLY '6000';
  23    1       DECLARE times$up LITERALLY '01H';

  24    1       WAIT: PROCEDURE REENTRANT PUBLIC;

  25    2   (R)     time$out$msg$ptr=RQWAIT(.min$5$ex,20);
  26    2           RETURN;
```

```
 27   2      END;

 28   1      TIMER5: PROCEDURE PUBLIC;
 29   2          min$5$up=0;

                /* enter task loop */

 30   2          DO WHILE 1;
 31   3      (S) time$out$msg$ptr=RQWAIT(.min$5$ex,five$minute$delay$count);
 32   3          min$5$up=times$up;
 33   3          END; /* of do while 1 */
 34   2      END; /* of procedure */
 35   1      END; /* of module */
```

```
ISIS-II PL/M-80 V3.1 COMPILATION OF MODULE REPORT
OBJECT MODULE PLACED IN :F1:RPTMOD.OBJ
COMPILER INVOKED BY:  plm80 :F1:RPTMOD.plm DEBUG DATE(10/12/78) PAGEWIDTH(78)


  1            REPORT:
                   DO;

               /*****************************************************************

                   This module contains the code for the REPORT
                   task that prints formatted reports of system
                   status upon command. Commands come in from
                   PRTREQ exchange with type=100 for todays
                   status report and type = 101 for yesterday's
                   status report. PRINT is the FORTRAN routine
                   that does the actual work.

               *****************************************************************/

               $nolist

 21   1      PRINT: PROCEDURE (file$ptr,name$size,request$type) EXTERNAL;
 22   2          DECLARE (file$ptr,name$size) ADDRESS;
 23   2          DECLARE request$type BYTE;
 24   2      END PRINT;

 25   1      FQFSET: PROCEDURE(A,ERRH) EXTERNAL;
 26   2      DECLARE (A,ERRH) ADDRESS;
 27   2      END FQFSET;

 28   1      DECLARE prt$req (10) BYTE PUBLIC;

 29   1      REPORT: PROCEDURE PUBLIC;

 30   2      DECLARE today$type LITERALLY '100';
 31   2      DECLARE yesterday$type LITERALLY '101';
 32   2      DECLARE (ptr,dummy) ADDRESS;
 33   2      DECLARE msg BASED ptr STRUCTURE(
                   link ADDRESS,
                   length ADDRESS,
                   type BYTE,
                   home$exchange ADDRESS,
                   response$exchange ADDRESS);
 34   2      DECLARE today$file$name (*) BYTE DATA(':D0:TODAYS.RPT');
 35   2      DECLARE ystday$file$name (*) BYTE DATA(':D0:YSTDAY.RPT');

               /* initialize math handler */

 36   2      dummy=0;
 37   2      CALL FQFSET(.dummy,.dummy);

               /* enter task loop */

 38   2          DO WHILE 1;
 39   3      (T) ptr=RQWAIT(.prt$req,0);

 40   3          IF msg.type=today$type THEN
 41   3              CALL print(.today$file$name,SIZE(today$file$name),.msg.t
          -   ype);
 42   3          ELSE IF msg.type=yesterday$type THEN
 43   3              CALL print(.ystday$file$name,size(ystday$file$name),.msg
          -   .type);
              CALL RQSEND(msg.response$exchange,ptr);
 45   3          END; /* of do while */
 46   2      END; /* of task */
 47   1      END REPORT;
```

```
ISIS-II FORTRAN-80      COMPILATION OF PROGRAM UNIT HEADER
OBJECT MODULE PLACED IN :F1:PRNTMD.OBJ
COMPILER INVOKED BY:  FORT80 :F1:PRNTMD.FRT DEBUG DATE(10/12/78) PAGEWIDTH(78)


  1             SUBROUTINE HEADER
                C
                C-- CALLED BY PRINT TO OUTPUT REPORT HEADER
                C
  2             WRITE(6,200)
  3       200   FORMAT('  DATE      TIME    PH     VOLUME      TEMP     DISSOLVED
                     -',
                1'TOTAL  ORGANIC  SUSPENDED PHOSPHATE INFLUENT EFFLUENT ',
                2'TURBID  AIR DIS MIX INF')
  4             WRITE(6,201)
  5       201   FORMAT(44X,'OXYGEN     CARBON  CARBON      SOLIDS     CONC',6X,
                1'FLOW      FLOW')
  6             WRITE(6,202)
  7       202   FORMAT(24X,'(CU.M)       (C)        (MG/ML)    (MG/ML) (MG/ML)    '
                     -',
                1'(MG/ML)    (MG/ML)    (MG/ML)   (MG/ML)     %')
  8             RETURN
  9             END
```

```
ISIS-II FORTRAN-80      COMPILATION OF PROGRAM UNIT PRINT
OBJECT MODULE PLACED IN :F1:PRNTMD.OBJ
COMPILER INVOKED BY:  FORT80 :F1:PRNTMD.FRT DEBUG DATE(10/12/78) PAGEWIDTH(78)


                C
                C-- SUBROUTINE PRINT CALLED BY REPORT TO GENERATE FORMATTED
                C-- REPORTS.  PRINTS EITHER TODAY'S FILE OR YESTERDAY'S
                C-- DEPENDING ON FILNM INPUT VALUE.
                C
  1             SUBROUTINE PRINT(FILNM,TYPE)
  2             IMPLICIT LOGICAL (A-Z)
  3             CHARACTER*14 FILNM
  4             INTEGER*2 ERRFLG,RECCNT,LSTREC
  5             INTEGER*1 TYPE
  6             INTEGER*1 INDEX
  7       $INCLUDE(:F1:EQUIV.DEC)
  8     =       CHARACTER BUFFER*57,PARAMS(57)*1
  9     =       REAL PH,VOLUME,TEMP,DISOXY,TOTCAR,ORGCAR
 10     =       REAL SUSSOL,PHOSFT,INFLOW,EFLFLO,TURBID
 11     =       INTEGER*1 DIGDAT
 12     =       INTEGER*2 MONTH,DAY,YEAR,HOUR,MINUTE,SECOND
 13     =       EQUIVALENCE (PARAMS,BUFFER)
 14     =       EQUIVALENCE (PARAMS,PH)
 15     =       EQUIVALENCE (PARAMS(5),VOLUME)
 16     =       EQUIVALENCE (PARAMS(9),TEMP)
 17     =       EQUIVALENCE (PARAMS(13),DISOXY)
 18     =       EQUIVALENCE (PARAMS(17),TOTCAR)
 19     =       EQUIVALENCE (PARAMS(21),ORGCAR)
 20     =       EQUIVALENCE (PARAMS(25),SUSSOL)
 21     =       EQUIVALENCE (PARAMS(29),PHOSFT)
 22     =       EQUIVALENCE (PARAMS(33),INFLOW)
 23     =       EQUIVALENCE (PARAMS(37),EFLFLO)
 24     =       EQUIVALENCE (PARAMS(41),TURBID)
 25     =       EQUIVALENCE (PARAMS(45),DIGDAT)
 26     =       EQUIVALENCE (PARAMS(46),MONTH)
 27     =       EQUIVALENCE (PARAMS(48),DAY)
 28     =       EQUIVALENCE (PARAMS(50),YEAR)
 29     =       EQUIVALENCE (PARAMS(52),HOUR)
 30     =       EQUIVALENCE (PARAMS(54),MINUTE)
 31     =       EQUIVALENCE (PARAMS(56),SECOND)
 32             CHARACTER*3 AIR,MIX,INFLNT,DISCHG
 33             COMMON /LSTREC/ LSTREC
                C
                C-- INITIALIZE RECORD COUNT
                C
 34             RECCNT=1
                C
                C-- INITIALIZE INDEX
                C
 35             INDEX=1
                C
                C-- OUTPUT HEADER
                C
 36             CALL HEADER
                C
```

```
      C-- WAIT FOR FILE ACCESS IF TODAY'S FILE
      C
37    1     IF(TYPE.EQ.100) CALL LOCK(2)
38          OPEN(8,FILE=FILNM,STATUS='OLD',IOSTAT=ERRFLG,
     (U)   1ERR=9000,ACCESS='DIRECT',RECL=57)
39    10    READ(8,REC=RECCNT,IOSTAT=ERRFLG,ERR=9100) BUFFER
40          RECCNT=RECCNT+1
41          IF((DIGDAT.AND.#01H).EQ.#01H) THEN
42          AIR=' ON'
43          ELSE
44          AIR='OFF'
45          ENDIF
46          IF((DIGDAT.AND.#02H).EQ.#02H) THEN
47          MIX=' ON'
48    (V)   ELSE
49          MIX='OFF'
50          ENDIF
51          IF((DIGDAT.AND.#04H).EQ.#04H) THEN
52          DISCHG=' ON'
53          ELSE
54          DISCHG='OFF'
55          ENDIF
56          IF((DIGDAT.AND.#08H).EQ.#08H) THEN
57          INFLNT=' ON'
58          ELSE
59          INFLNT='OFF'
60          ENDIF
61          WRITE(6,101) MONTH,DAY,YEAR,HOUR,MINUTE,SECOND,
           1PH,VOLUME,TEMP,DISOXY,TOTCAR,ORGCAR,SUSSOL,PHOSFT,
           2INFLOW,EFLFLO,TURBID,AIR,DISCHG,MIX,INFLNT
62    101   FORMAT(I2,'/',I2,'/',I2,1X,I2,':',I2,':',I2,1X,F4.1,1X,F9.2,
           Z1X,F9.4,1X,F9.4,1X,F8.3,1X,F8.3,1X,F9.4,1X,F9.4,1X,F8.3,1X,F8.3
                 -,1X,F7.3,
           Z1X,A3,1X,A3,1X,A3,1X,A3)
      C
      C-- CHECK FOR END OF FILE AND OTHER THINGS
      C
63          INDEX=INDEX+1
64          IF(TYPE.EQ.100) THEN
65          IF(INDEX.LE.10) THEN
66          IF(RECCNT.LT.LSTREC) THEN
67          GOTO 10
68          ELSE
69          CLOSE(8,IOSTAT=ERRFLG,ERR=9200)
70          CALL UNLOCK(2)
71    (W)   RETURN
72          ENDIF
73          ELSE
74          INDEX=1
75          CLOSE(8,IOSTAT=ERRFLG,ERR=9200)
76          CALL UNLOCK(2)
77          GOTO 1
78          ENDIF
79          ELSE
80          IF(RECCNT.LE.288) THEN
81          GOTO 10
82          ELSE
83          CLOSE(8,IOSTAT=ERRFLG,ERR=9200)
84          RETURN
85          ENDIF
86          ENDIF
      C
      C-- ERROR HANDLERS
      C
87    9000  WRITE(6,9001) ERRFLG
88    9001  FORMAT('OPEN ERROR IN PRINT; #',I4)
89          RETURN
90    9100  WRITE(6,9101) ERRFLG
91    9101  FORMAT('READ ERROR IN PRINT; #',I4)
92          RETURN
93    9200  WRITE(6,9201) ERRFLG
94    9201  FORMAT('CLOSE ERROR IN PRINT; #',I4)
95          RETURN
96          END
```

```
PL/M-80 COMPILER                                        10/12/78   PAGE   1

ISIS-II PL/M-80 V3.1 COMPILATION OF MODULE INITMD
OBJECT MODULE PLACED IN :F1:INITMD.OBJ
COMPILER INVOKED BY:  plm80 :F1:INITMD.plm DEBUG DATE(10/12/78) PAGEWIDTH(78)


   1          INITMD:
                  DO;

              $nolist

  16   1      FQ0GO: PROCEDURE EXTERNAL;
  17   2      END FQ0GO;

  18   1      DECLARE semaphore (3) ADDRESS EXTERNAL;
  19   1      DECLARE token (3) STRUCTURE(
                  msgShdr) EXTERNAL;

  20   1      INIT: PROCEDURE PUBLIC;
  21   2      DECLARE i BYTE;

  22   2 (X)      CALL FQ0GO;

              /* initialize semaphores */

  23   2          DO i=0 TO 2;
  24   3 (Y)      CALL RQSEND(semaphore(i),.token(i));
  25   3          END;

              /* PROGRAM THE 8255 */

  26   2          OUTPUT(0EBH)=92H;

              /* TURN OFF ALL ALARMS */

  27   2 (Z)      OUTPUT(0EAH)=0;

  28   2      RETURN;
  29   2      END;
  30   1      END INITMD;



ASM80.OV3 :F1:X2CFG.M80 DEBUG PAGEWIDTH(78)

ISIS-II 8080/8085 MACRO ASSEMBLER, V2.0         X2CFG    PAGE    1

  LOC  OBJ          SEQ          SOURCE STATEMENT

                      1          NAME    X2CFG
                      2          CSEG
                      3          PUBLIC  RQRATE
  0000 2000           4 RQRATE:  DW      32
                      5 $NOLIST
                    360 $LIST
                    361 $NOGEN
  0000              362 NTASK    SET     0
  0000              363 NEXCH    SET     0
  0000              364 NDEV     SET     0
  0000              365 NCONT    SET     0
                    366 ;
                    367 ;        BUILD INITIAL TASK TABLE
                    368 ;
                    369          STD     RQADBG,64,129,RQWAKE
                    426          STD     RQTHDI,36,112,RQOUTX
                    483          STD     RQPDSK,48,129,RQDSKX
                    540          STD     RQPDIR,48,130,RQDIRX
                    597          STD     RQPDEL,64,131,RQDELX
                    654          STD     RQPRNM,64,132,RQRNMX
                    711          STD     RQAIH,34,133,RQAIEX
                    768          EXTRN   RQHD1
                    769          CONSTD  CNTROL,RQHD1,80,CNSTK,81,CONTEX
                    882          STD     TIMER,64,20,0
                    939          STD     TIMUPD,64,140,0
                    996          STD     TIMER5,64,141,0
                   1053          STD     STSINP,64,142,0
                   1110          STD     CHANGE,64,143,0
                   1167          STD     REPORT,800,144,0,18
                   1224 (AA)     STD     SCAN,800,144,0,18
                   1281 ;
                   1282 ;        ALLOCATE TASK DESCRIPTORS
                   1283 ;
                   1284          GENTD
                   1288 ;
                   1289 ;        ALLOCATE EXCHANGES
                   1290 ;
                   1291          XCH     CONTEX
                   1295          XCH     FQ0LOK
```

```
                                  (BB)
1299                      INTXCH  RQL5EX
1305 ;
1306 ;                   BUILD INITIAL EXCHANGE TABLE
1307 ;
1308                      XCHADR  RQDSKX
1315                      XCHADR  RQDIRX
1322                      XCHADR  RQRNMX
1329                      XCHADR  RQDELX
1336                      XCHADR  RQAIEX
1343                      PUBXCH  CONTEX
1350                (CC)  PUBXCH  RQL5EX
1357                      PUBXCH  FQØLOK
1364                      XCHADR  RQINPX
```

```
LOC  OBJ          SEQ          SOURCE STATEMENT

                  1371         XCHADR  RQOUTX
                  1378         XCHADR  RQDBUG
                  1385         XCHADR  RQWAKE
                  1392         XCHADR  RQALRM
                  1399         XCHADR  RQL6EX
                  1406         XCHADR  RQL7EX
                  1413         XCHADR  STSLOK
                  1420         XCHADR  SETLOK
                  1427         XCHADR  DSKLOK
                  1434         XCHADR  BMPTIM
                  1441         XCHADR  TIMPOL
                  1448         XCHADR  PRTREQ
                  1455         XCHADR  CHRESP
                  1462         XCHADR  ANRESP
                  1469         XCHADR  MIN5EX
                  1476         XCHADR  TIMEEX
                  1483         XCHADR  RDRESP
                  1490 ;
                  1491 ;       BUILD CREATE TABLE
                  1492 ;
                  1493         CRTAB
                  1500 ;
                  1501 ;       BUILD DEVICE CONFIGURATION TABLE
                  1502 ;
                  1503         DCT     DØ,Ø,Ø,Ø
                  1544         DCT     D1,Ø,Ø,1
                  1585 ;
                  1586 ;       BUILD CONTROLLER SPECIFICATION TABLE
                  1587 ;
                  1588         CST     Ø,8ØH,5,RQL5EX,CONTEX
                  1604 ;
                  1605 ;       BUILD BUFFER ALLOCATION BLOCK
                  1606 ;
                  1607         BAB     3,BUFPOL
                  1627         END
```

```
PL/M-8Ø COMPILER                                    1Ø/12/78   PAGE   1


ISIS-II PL/M-8Ø V3.1 COMPILATION OF MODULE CAMMOD
OBJECT MODULE PLACED IN :F1:CAM.OBJ
COMPILER INVOKED BY:  plm8Ø :F1:CAM.plm DEBUG DATE(1Ø/12/78) PAGEWIDTH(78)


   1          CAMMOD:
                 DO;
              /* CONTROLLER TASK STACK */
   2   1          DECLARE CN$STK (8Ø) BYTE PUBLIC;
         (DD) /* DFS INTERNAL BUFFER SPACE */
   3   1          DECLARE RQDBUF (7ØØ) BYTE PUBLIC;
              /* DFS STATIC BUFFER POOL */
   4   1          DECLARE BUF$POL (12ØØ) BYTE PUBLIC;

   5   1      END CAMMOD;
```